DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

SYSTEMS ANALYSIS FOR
LARGE ARMY FORMATIONS

by

Spyridon Kalyvas

June 1984

Thesis Advisor: N.R. Lyons

Approved for public release; distribution unlimited.

T222194

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Systems Analysis for Large Army Formations		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; June 1984 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Spyridon Kalyvas		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		12. REPORT DATE June 1984 13. NUMBER OF PAGES 104
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Army Systems Analysis

Large Army Formations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The current functional doctrines of the Large Army Formation (Corp, Division, Brigade) Command Posts are, more or less, refined extensions of doctrinal concepts which were in use for three centuries. These functional doctrines have survived until today because they have been in general successful and effective. Today however we are entering a new era. New effective weapon systems, often with embedded computers, introduce the impersonal

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

#20 - ABSTRACT - (CONTINUED)

mass destruction of the enemy by long-range indirect and direct fire, requiring complete, precise and especially timely information on the battlefield status. Thus the traditional staff function will not be effective enough in the modern warfare unless automated information processing means are studied, designed, developed and used.

This thesis analyzes the Large Army Formation (LAF) as an information system, identifies and defines the functional automation of the staff and provides a preliminary and basic source study for future detailed investigation on the feasibility and utility of the automation in the Greek Large Army Formations.

Approved for public release; distribution unlimited.

Systems Analysis for Large Army Formations

by

Spyridon Kalyvas
Captain, Hellenic Army
B.S., Military Academy of Athens, 1972
B.S., Advanced School of Communication Electronics, 1978

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL

June 1984

DUDLEY KNOX LIBRARY
43
Thesis
K12432
c.1

ABSTRACT

The current functional doctrines of the Large Army Formation (Corp, Division, Brigade) Command Posts are, more or less, refined extensions of doctrinal concepts which were in use for three centuries. These functional doctrines have survived until today because they have been in general successful and effective. Today however we are entering a new era. New effective weapon systems, often with embedded computers, introduce the impersonal mass destruction of the enemy by long-range indirect and direct fire, requiring complete, precise and especially timely information on the battlefield status. Thus the traditional staff function will not be effective enough in the modern warfare unless automated information processing means are studied, designed, developed and used.

This thesis analyzes the Large Army Formation (LAF) as an information system, identifies and defines the functional automation of the staff and provides a preliminary and basic source study for future detailed investigation on the feasibility and utility of the automation in the Greek Large Army Formations.

KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943

TABLE OF CONTENTS

I. THE LAF AS AN INFORMATION SYSTEM ---------- 10

A. MISSION, GOAL AND OBJECTIVES OF THE LAF ----- 10

B. THE LAF: A SYSTEM OF SYSTEMS ---------- 14

C. THE LAF'S INFORMATION NEEDS ---------- 17

II. MODELING A STAFF ASSISTANT COMPUTER SYSTEM (SACS) ---------- 24

A. AUTOMATION NEEDS--EXPECTATIONS ---------- 24

B. PROBLEMS ---------- 25

C. SACS DEFINITION ---------- 25

D. SACS HARDWARE COMPONENTS DESCRIPTION -------- 26

E. SACS HARDWARE TOPOLOGY AND WORKSTATIONS ----- 29

F. SACS SOFTWARE COMPONENTS DESCRIPTION -------- 30

III. WORKING WITH THE SACS ---------- 43

A. PERSONNEL FUNCTIONS ---------- 43

B. INTELLIGENCE FUNCTIONS ---------- 43

C. OPERATIONS FUNCTIONS ---------- 46

D. LOGISTICS FUNCTIONS ---------- 48

IV. SECURITY AND SACS ---------- 52

A. SACS SECURITY INTO PERSPECTIVE ---------- 52

B. SECURITY AND THE LIFE CYCLE OF SACS --------- 54

C. SURVIVABILITY OF THE SACS ---------- 57

D. NETOWRKING THE SACS WITH SECURITY ---------- 58

V. FACING THE END USER PROBLEM ---------- 62

A. THE END USERS OF THE SACS ---------- 62

B. THE QUERY LANGUAGE ---------- 63

C. THREE PROBLEM SOLVING SCENARIOS ---------- 67

VI. INTELLIGENCE INFERENCE AND DECISION MAKING ------ 78

A. THE MILITARY INTELLIGENCE PROBLEM ---------- 78

B. THE TACTICAL INTELLIGENCE MODEL ---------- 80

C. THE TARGET DETECTION MODEL ---------- 83

D. THE "TWO LOOKS" MODEL ---------- 84

E. THE "WHAT THE ENEMY IS GOING TO DO" MODEL --- 87

VII. EPILOG ---------- 96

APPENDIX A: PROGRAM LISTING ---------- 98

LIST OF REFERENCES ---------- 103

INITIAL DISTRIBUTION LIST ---------- 104

LIST OF FIGURES

1.1 LAF's Mission-Objective-Goal Network ---------- 19

1.2 LAF is a Closed Loop System ---------- 20

1.3 LAF is a System of Systems ---------- 21

1.4 LAF is an Information Dependent System ---------- 22

1.5 LAF Information Requirements and Uses ---------- 23

2.1 Automation Needs--SACS Expectations ---------- 38

2.2 SACS HW Configuration ---------- 39

2.3 Mapping of Detection Systems on the LDP --------- 40

2.4 Operations Workstation ---------- 41

2.5 Personnel Workstation (Up); Intelligence Workstation (Down) ---------- 42

3.1 Intelligence Subsystem Data Flow Diagram -------- 50

3.2 Operations Subsystem Data Flow Diagram ---------- 51

4.1 End-to-End Encryption Using PLIs ---------- 60

4.2 PLI Layout ---------- 61

5.1 Data Flow Diagram of QBPE ---------- 77

6.1 Transition Probability Tree ---------- 91

6.2 Unconditioned Probability Space ---------- 92

6.3 Conditioned Probability Space ---------- 93

6.4 Union of Sensors and Errors of Types a & b ------ 94

6.5 Improvement of Later Sensors over First Sensor -- 95

LIST OF ACRONYMS

BIR	Battlefield Information Reports
CCC	Center to Center Communications
CTC	Common Tactical Console
DMM	Detection Mapping Modulator
EOB	Enemy Order of Battle
ESD	Enemy Situation Data
GESS	Geometric Engine Style Subsystem
LAF	Large Army Formation
LDP	Large Display Panel
LMC	LAF's Main Computer
MIC	Management of Intelligence Collection
NAI	Named Area of Interest
OQS	On-line Query System
OPBE	Office Procedures By Example
PCU	Peripheral Control Unit
QBE	Query By Example
QBPE	Query By Pictorial Example
SACS	Staff Assistant Computer System
SPCU	Special Prupose Control Unit
SWF	Staff Working File
TAC	Tactical Analysis Console
TD	Tactical Dispositions
TF	Terrain File

TO	Task Organization
UOR	Unit Operations Report
WF	Weather File

I. THE LAF AS AN INFORMATION SYSTEM [1,2,3]

A. MISSION, GOAL, AND OBJECTIVES OF THE LAF

1. Definition of the LAF

The LAF is an army unit that comprises a balanced force of essential ground arms and services so organized and equipped as to make it tactically and administratively self-contained. That is, it can conduct by its own means ground operations of general importance. It can strike or penetrate effectively, maneuver readily over any type of terrain and absorb reinforcing units easily.

2. Mission of the LAF

The mission of the LAF can be any or all of the following:

a. To seize and secure an area and to deny its use to the enemy.

b. To dominate key or vital land areas and their population and resources.

c. To destroy or capture enemy military forces.

3. Goal of the LAF

The goal of the LAF is the successful fulfillment of its specified mission.

4. Objectives[1] of the LAF

The objectives of the LAF are concrete and specific accomplishments necessary to the achievement of its goal. The main objectives of the LAF are:

a. With respect to Personnel
   - Good Health
   - High degree of Training and Education
   - Discipline and High Morale

b. With respect to Equipment[2]
   - High Performance
   - Good Maintenance

c. With respect to Functionality
   - Precision
   - Actions in Time
   - Effectiveness
   - Low Cost

5. Dependency and Relations Among Mission, Objectives and Goal

The mission of the LAF is expressed by the military manuals in a general manner and needs to be specified explicitly either by the orders of the LAF's superior echelon or by the LAF's command. This specification is an aftermath of considerations of several factors like the strength and the operational ability of the LAF, the strength and behavior

---

[1]These must not be confused with the terrain objectives on the battlefield.

[2]Weapons, Munition, Ammunition, Vehicles, Facilities, Supplies.

of the enemy, the land morphology, the weather conditions. As these factors are related to time, they confound the tactical situation. The mission's specification is an adaptation over time. The estimation of the situation is a continuing process and changed conditions may call for a new decision at any time that could modify the mission's specification.

The objectives of the LAF are dependent on the mission's adaptation in a considerable way. For example, military operations conducted under conditions of extreme cold and deep snow require special equipment and training for the LAF designated to conduct such operations. The objectives are also strongly related to each other. For example, a high degree of personnel training results in good maintenance and performance of the equipment. The high performance of the equipment facilitates the personnel training. A high degree of personnel training and high performance of the equipment leads to an effective functioning of the system.

The achievement of the LAF's goal is exclusively dependent on the accomplishment of its objectives. Moreover, the achievement or failure of the goal can cause an adaptation of the mission. For example, after a successful attack when the enemy is no longer able to maintain his position, then the mission of the LAF must enter a new phase; a pursuit must be launched.

Figure 1.1 shows the dependency and the relations among mission, objectives and goal of the LAF.

6. The LAF Is a Closed Loop System

A system is a combination of diverse but interacting elements integrated to achieve its overall purpose. The elements may be devices and/or human beings concerned with processing materials, information and energy. A feedback loop for returning part of the output to the input in order to improve performance is an important functional component in many systems. The concept of feedback is not new; it is inherent in many biological systems, and it is found in well-established social systems. However the formulation of the principles of feedback is a recent achievement, credited to H.S. Black in his studies in 1934, and exploitation of this new understanding has come in just the last few years.

The LAF is a feedback or a closed loop system. That is, it provides command and staff with a comparison of both actual and desired output. The input of the LAF is its specified mission, the desired output is either the accomplishment of its objectives in the time of peace or the achievement of its goal in the time of war. This comparison can trigger the LAF's command and staff to take action in order to bring desired and actual output into correspondence. So the comparison of desired and actual output requires an explicitly documented specification of the mission and a measurement of the actual output. The measurement of the actual output comes from either evaluations with respect to the LAF's objectives or the estimation of the situation with respect to the LAF's goal.

Each closed loop or feedback system is effective if it can respond fast for the necessary control action. Otherwise the time lapse maybe so great that belated control action can make the situation worse [Ref. 1, p. 61]. Such systems are said to be unstable. In an unstable system, a random disturbing input may give rise to decoordination of the system. The LAF is an unstable system, thus a sudden unforeseen enemy action, the lack of fast control response or misestimation of the situation can often be a catastrophe for the LAF. By nature, an unstable system is difficult to control. On the other hand, the requirements for certain results of a military action impose difficult planning problems for the staff, who are the control engineers of the LAF. The use of automated tools will be, if not a panacea, at least a means to maximize the control abilities of the staff and to minimize the unforeseen situations.

Figure 1.2 presents the LAF as a closed loop system.

B. THE LAF: A SYSTEM OF SYSTEMS

The LAF is a system which is composed of two smaller entities which are also systems. These systems are the LAF's staff, a planning and control functional system and the totality of the LAF subordinate echelons which constitute an executive system. These systems are also divided into subsystems. This work focuses on the staff since the subsystems of the executive system (small groups and units) are beyond its scope.

The Staff and Its Subsystems

The mission of the staff is:

1. To conduct methodical analysis of any tactical or procedural problem in the activities of the LAF, to elaborate fast, precise and satisfactory solutions and to present these solutions to the LAF's Commander General Officer in order to reach a decision.
2. To interpret with accuracy the decisions of the General into orders and to issue these orders at the proper time.
3. To always be informed in time on the situation and to be sure that all the relevant factors have been considered.
4. To be able to quickly control and coordinate the operations.
5. To minimize the probability of errors.
6. To relieve, as much as possible, the Commander General from the supervision of activities that are not vitally important.

The basic subsystems of the staff are those of personnel, intelligence, operations and logistics. These subsystems have a number of significant functions that should be considered.

1. Personnel

Personnel functions are intended to keep the LAF informed on personnel strength, the administrative situation,

the current battle personnel needs and changes in priority. These functions include:

a. Developing Estimates

b. Maintaining LAF's Strength Status

c. Supervision of Personnel Management.

2. Intelligence

Intelligence functions are intended to provide the LAF with intelligence information on which to base current tactical decisions. The functions performed include:

a. Planning of Information Collection

b. Information Collection Management

c. Information Analysis and Verification

d. Dissemination of Analysis Products

e. Coordination of Counterintelligence

f. Coordination of Informants

g. Planning and Coordination of Reconnaissance.

3. Operations and Training

Operations and training functions are intended to support the LAF by having highly trained personnel and by controlling immediate combat operations and sustaining battle. The functions performed include:

a. Preparation of Training and Education Plans

b. Coordination of Training

c. Coordination and Processing Evaluations

d. Preparation of Operation Plans

e. Coordination of Tactical Troop Movements

f. Coordination of Nuclear and Chemical Weapons

g. Maintaining an Operation's Estimate

h. Planning and Processing Air Support Requests

i. Supervision of Electronic Warfare.

4. Logistics

Logistics functions are intended to coordinate the logistics requirements of the LAF with the tactical aspects of the LAF's activities. The functions performed include:

a. Planning Supply, Services, and Maintenance

b. Monitoring the Logistic Situation and Capability

c. Monitoring the Medical Activity

d. Monitoring the Airlifting of the LAF.

A well-working staff speeds up the elaboration of the information and transforms it to useful material for decision making. The introduction of automated information processing means will make the staff more productive by minimizing the delays in the preparation and distribution of the estimations, plans, and directions.

C. THE LAF'S INFORMATION NEEDS

The information that a LAF must elaborate to meet its operational needs is generated by its internal reporting structure and by its external environment as well.

The information generated is not simply useful to any army unit but is of vital importance. The whole mission's adaptation is based on the information generated in the LAF's

internal and external environment. Good exploitation of information leads to better estimations of the situation which leads to better decision making. Lack of information or misinterpretation of the information may be fatal, not only for the success of a tactical action on the battlefield but also for the existence of the unit itself. We could say that no tactical action is possible without information--it is the oxygen for every army organism on the battlefield. Because of this "starvation" for information, there is the intelligence subsystem of the staff which has as its primary role the coverage of the needs of the LAF for exploitable information.

Fig. 1.4 shows the LAF's main information generators.

At each management level, the specific requirements for information vary. The different information uses and requirements at each command & management level are summarized in Fig. 1.5.

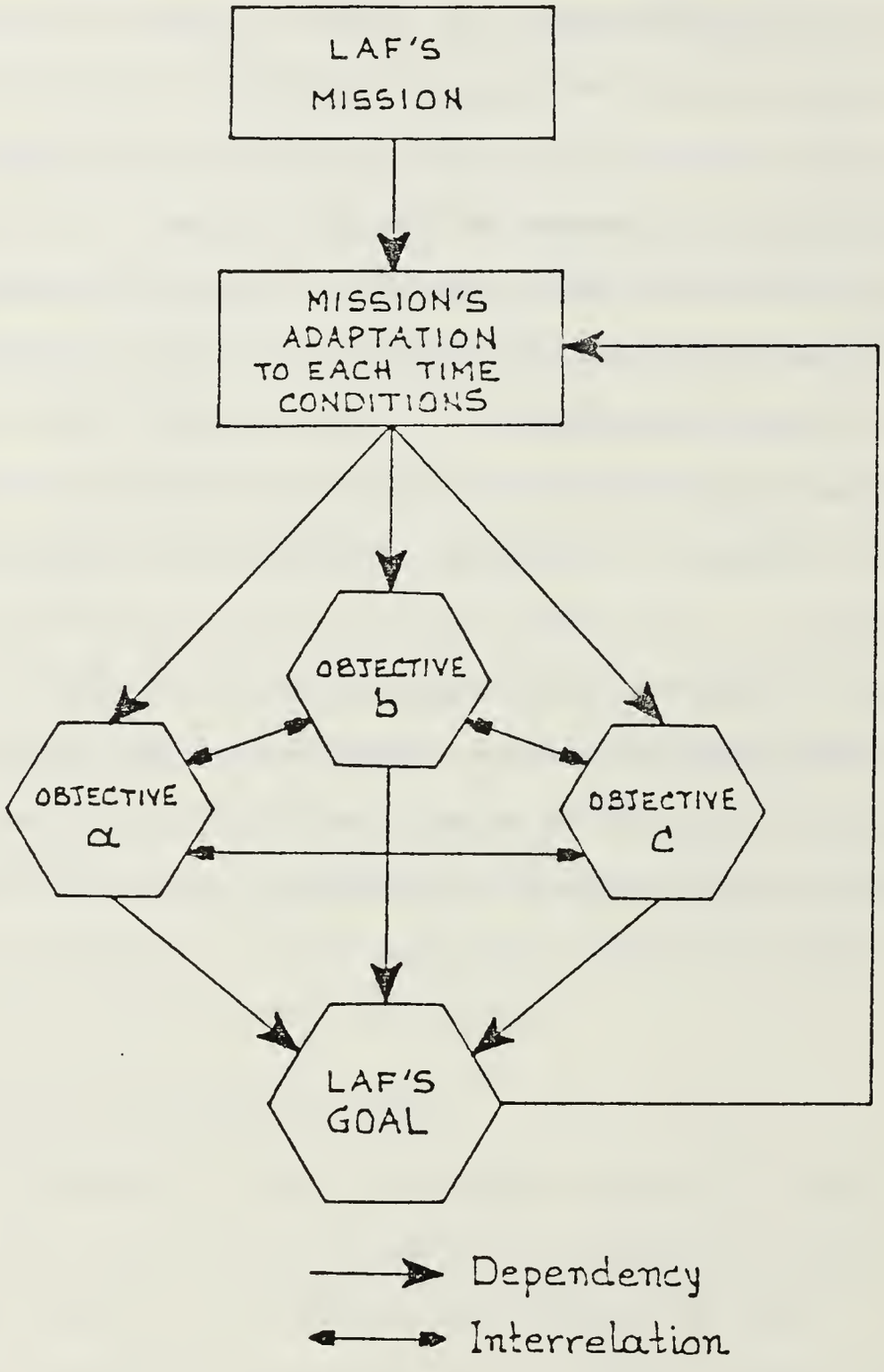


Figure 1.1: LAF's Mission-Objective-Goal Network.

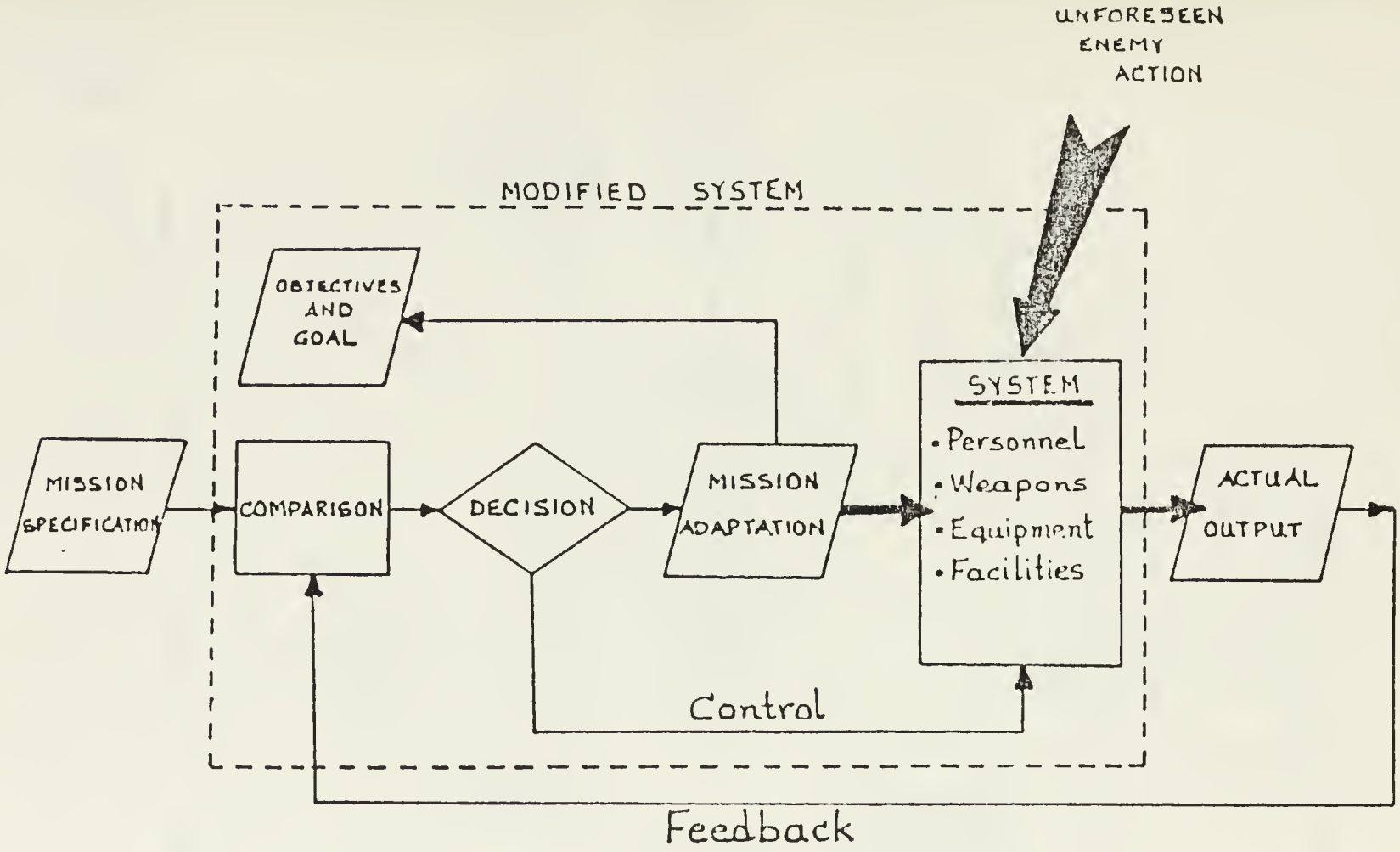


Figure 1.2: LAF is a Closed Loop System.

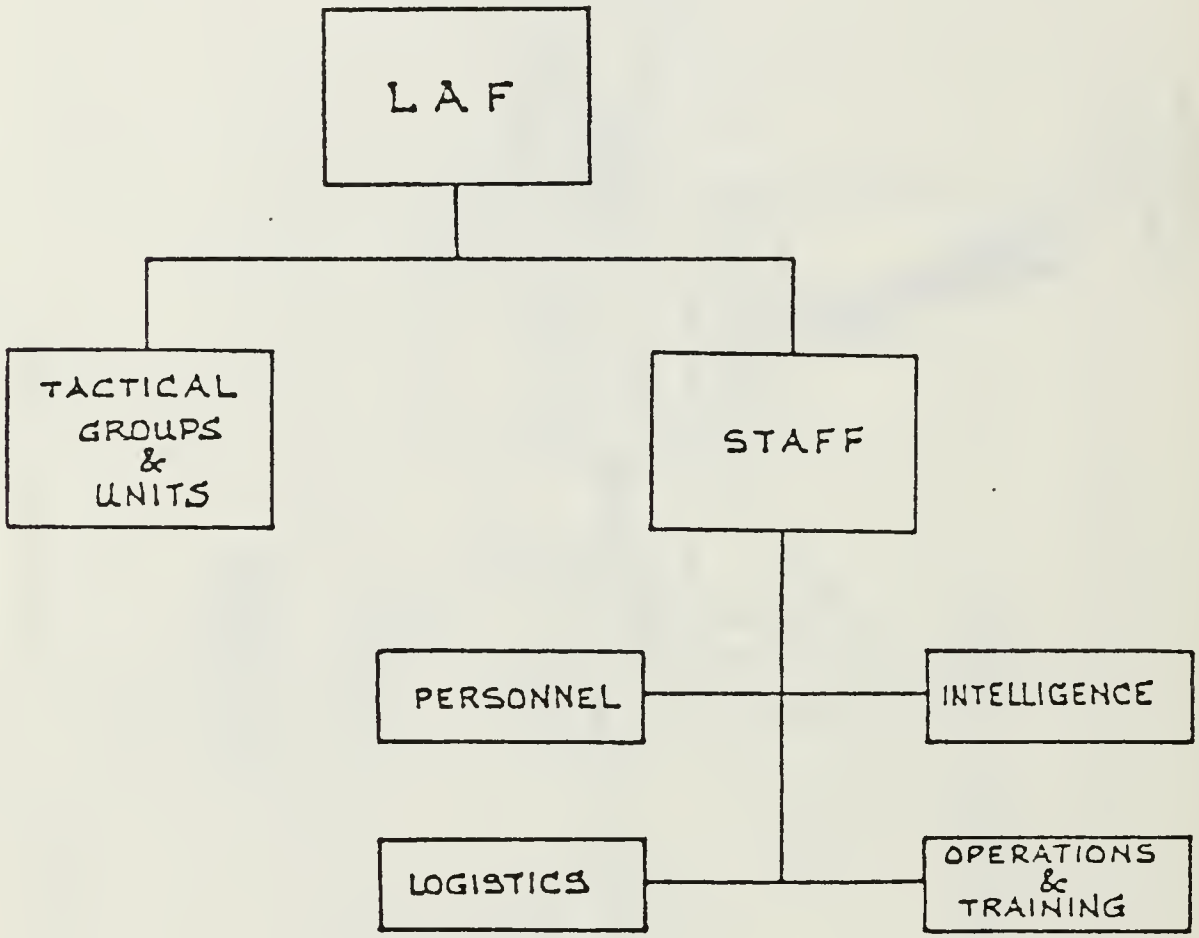


Figure 1.3: LAF is a System of Systems.

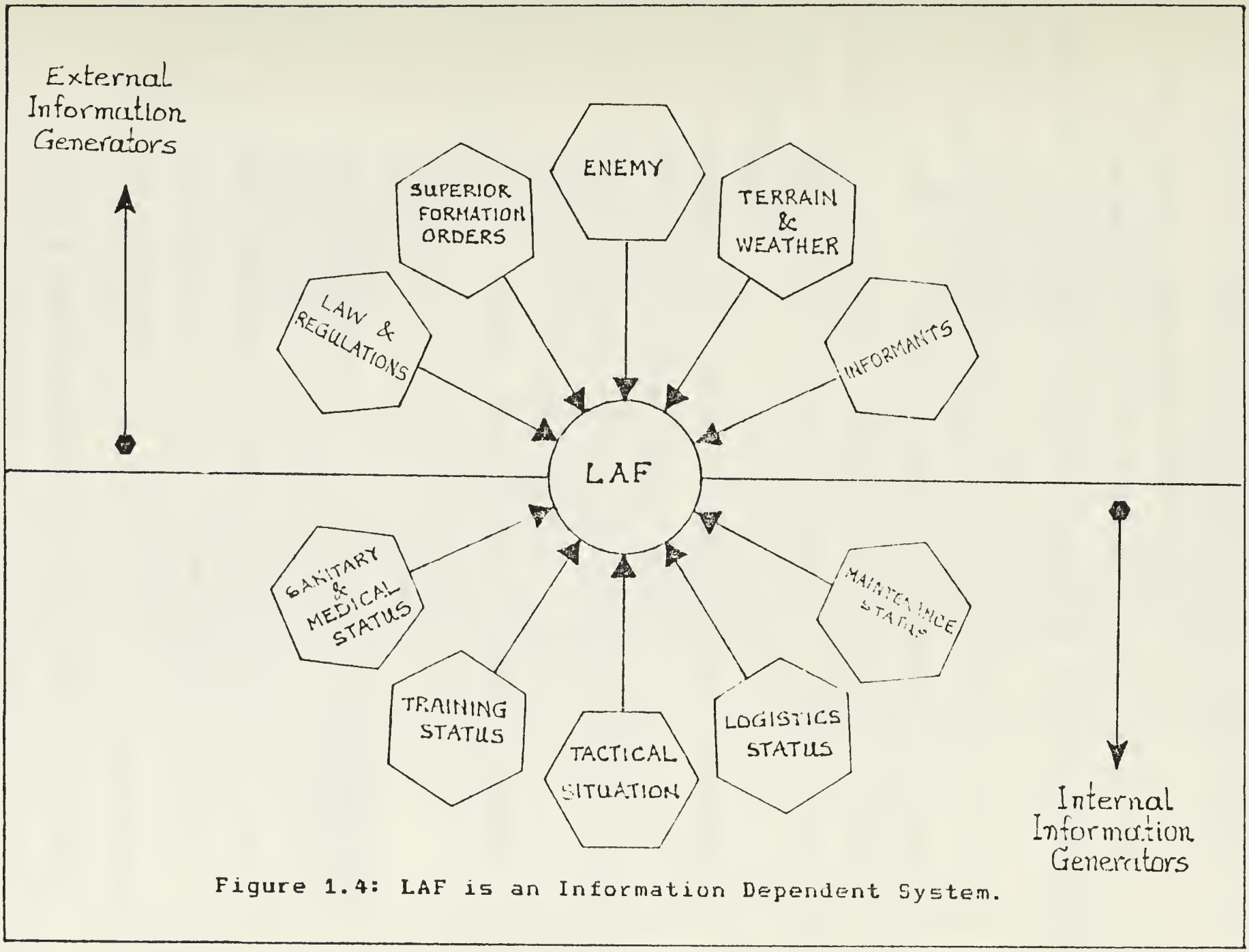


Figure 1.4: LAF is an Information Dependent System.

COMMAND LEVEL	INFORMATION REQUIREMENTS	INFORMATION USE
GENERAL	1. EXTERNAL INFO. a. Superior LAF Orders b. Regulations c. Enemy d. Terrain & Weather 2. INTERNAL INFO. a. Suggestions of Staff & Commanders b. Inspections	1. GOAL SETTING 2. ESTIMATION OF SITUATION 3. ACCEPTANCE OR REJECTION OF SUGGESTIONS 4. DECISIONS 5. SUPERVISION OF VITAL ACTIVITIES
STAFF	1. EXTERNAL INFO. a. Superior LAF Orders b. Regulations c. Prisoners & Informants d. Terrain & Weather 2. INTERNAL INFO. a. Orders of the General b. Unit's Reports c. Evaluations of Subord. Units	1. OBJECTIVES DEFINITION 2. TRAINING PLANS 3. ESTIMATION OF TACTICAL SITUATION 4. OPERATIONAL PLANS 5. SUGGESTIONS TO GENERAL 6. OBJECTIVES ATTAINMENT
COMMANDS OF SUBORDINATE ECHELONS	1. EXTERNAL INFO. a. Regulations b. Enemy & Prisoners c. Terrain & Weather 2. INTERNAL INFO. a. Orders of the General b. Directions of Staff c. Inspections & Interviews	1. ESTIMATION OF TACTICAL SITUATION 2. SUGGESTIONS TO GENERAL 3. OBJECTIVES ATTAINMENT 4. SUPERVISION

Figure 1.5: LAF Information Requirements & Uses.

II. MODELING A STAFF ASSISTANT COMPUTER SYSTEM (SACS) [4,5]

A. AUTOMATION NEEDS--EXPECTATIONS

Before making the configuration of any computer system for assisting the staff functions, the needs of this system should be identified.

Although there are problems inherent in specifying the requirements to be met by something that does not yet exist (similar to convincing a farmer of his need for a tractor he has never seen), a SACS is expected to meet the following requirements:

1. Exchange data with other tactical data systems
2. Build and maintain data bases
3. Perform tactical analysis functions to support control actions and decision making
4. Provide displays and graphics to support tactical operations and daily procedures
5. Interface with detection systems
6. Provide functions to support tactical war games for the LAF's senior personnel training.

Figure 2.1 presents a matrix which lists the automation needs--expectations for the SACS, with respect to staff functional subsystems.

B. PROBLEMS

The expansion of automated assistance for staff activities is inevitably accompanied by two major problems:

1. The machine problem--that of making computing power available to staff personnel
2. The human problem--that of motivating staff personnel to utilize computers.

Attempting a solution to the first problem, a SACS model will be presented which, if completed and finally implemented, could insure the availability of computer resources throughout the staff environment. The solution to the problem of user motivation for exploitation of automated assistance will be embodied in a proposed user communications pattern.

C. SACS DEFINITION

SACS must be a secure, militarized, automatic system composed of the automatic data processing elements:

1. Hardware
2. Firmware
3. Software
4. Communications Network,

required for performing the receiving, filtering, processing, storing and correlating of input data and also for printing and disseminating the information product. This is to support the staff in increasing its productivity and the quality of its work and to support commanders in their decision making.

D. SACS HARDWARE COMPONENTS DESCRIPTION

SACS must have the following hardware components in order to accomplish its intended task.

1. LAF Main Computer (LMC)

The LMC must provide the major computing capability in the LAF. It must be able:

a. To maintain large data bases

b. To perform numerical calculations

c. To perform filtering

d. To perform correlation of information

e. To respond to queries

f. To support other required processes and algorithms

g. To accept and transmit messages from and to SACS users and interoperating systems

h. To perform color graphic compositions.

The LMC can be a supermini system in order to cover the above listed requirements, in a satisfactory way in terms of accuracy and fast response.

2. The Peripheral Control Unit

The PCU must be a small scale computer capable of storing messages and color[3] graphics data, prompting for message and color graphic composition and enabling the several consoles to interact with the LMC and to accept messages and pictures from the detection systems.

---

[3]The color is considered necessary to enable a vivid illustration of maps, friendly and foe force dispositions, etc.

3. The Tactical Analysis Console (TAC)

The TAC must provide the user with the capability to have color graphics and alphanumeric input and output with or without an illuminated color map background and color hard-copy output. TACs must be connected to PCUs and must have a color display, a keyboard, a "mouse," a printer, and a plotter. The TAC must be capable of input and output of formatted or free text and of providing the user with the capability to review, store, manipulate and disseminate data on request and automatically.

4. The Large Display Panel (LCP)

The LDP must be a computer driven large screen which will permit the integration of tactical command and control data on a universal traverse mercator map background and must facilitate user interaction with the data base. It must provide the user the capability to create new color displays interactively, display information from the data base through direct communication with the LMC or indirectly through a connection with a PCU, update the data base, and store and retrieve displays. The LDP must have sufficient memory for storing the display symbology used in conjunction with standard military maps.

5. The Geometry Engine (GE) Style Subsystem (GESS)

The GESS[4] must provide realistic visual simulation for real-time manipulation of geometry and other information taken

---

[4]See "The Geometry Engine, a VLSI Geometry System for Graphics," by J.H. Clark, Computer Graphics, July 1982.

by detection systems. The GESS must output smooth continuous curves of 2D and 3D transformations and sharp readable textual descriptions of the behavior of the corresponding displayed object pictures.

6. The Detection Mapping Modulator (DMM)

The DMM must interpret the signals which are received by the detection systems and which are interpreted locally into radar screen videos, into target geometric elements, and routed to the SPCU.

7. The Special Purpose Control Unit (SPCU)

The SPCU must have the capability to control the outputs of the DMM, to compose the target information collected by adjacent detection systems with overlapped observation areas into integrated target information of larger areas (e.g., the combat zone of the LAF), and to feed appropriately the GESS with the geometric elements of the corresponding targets.

8. The Common Tactical Console (CTC)

The CTC must be used for the display of, and interaction with computer stored data. It must be a small, transportable device capable of sending and receiving alphanumerics and unsophisticated graphics through the PCU. The CTC must be equipped with one color plasma display, a keyboard and a printer. For alphanumeric data, the CTC must provide the user the capability to display prompt message composition, edit messages, and input and output messages in formatted

or free text. For simple graphics data, the CTC must provide the user with the capability to create new displays interactively, display information from the database indirectly through connection with a PCU, update the database and store and retrieve displays of military symbology.

E. SACS HARDWARE TOPOLOGY AND WORKSTATIONS

SACS hardware components must be located at the LAF tactical command post and at some of its subordinate echelon commands.

1. LAF Tactical Operation Center
    a. the LMC
    b. the GESS, SPCU and DMM
    c. One PCU, one LDP, one TAC and one CTC
2. The Personnel Subsystem
    a. One PCU
    b. One CTC
3. The Intelligence Subsystem
    a. One PCU
    b. One TAC
    c. One CTC
4. The Operations Subsystem
    a. One PCU
    b. One LDP
    c. One TAC
    d. One CTC

5. The Logistics Subsystem

a. One PCU

b. One TAC

c. One CTC

Figures 2.4 and 2.5 show the workstation organizations of the several subsystems. Some CTCs should also be given to the subordinate commands of the LAF if the LAF happens to be an independent brigade. If the LAF is a larger unit then it will have subordinate LAFs having their own SACSs.

F. SACS SOFTWARE COMPONENTS DESCRIPTION

1. Enemy Situation Applications Software

a. Enemy Situation Data (ESD)

The ESD file must contain data and intelligence concerning enemy units, equipment, personnel, installations and activities. The application program associated with this file should provide for collection, storage, dissemination and selective retrieval of current enemy information. The major components of ESD file entries must be: intelligence subject; combat activity; unit element, equipment and location; morale; losses; weapon system activities; target identification and target characteristics. Related to each ESD message should be a list of users interested and authorized for the use of data contained in the message. Users authorized interest may be indicated in the following ways: (1) Users are specified as interested with the submission of the message; (2) An incoming ESD message satisfies the user criteria for a standing

request for information; (3) A reviewer of the incoming message determines those interested in the message. Authorized users of enemy information may indicate their interest in messages as a means of retrieving data from the file. All system users, collection agents and sources may and should provide data for this application. The ECD in few words should provide the basic intelligence reporting mechanism for system users and should form the basis for developing enemy order of battle, targeting and other processed intelligence.

b. Enemy Order of Battle (EOB)

The EOB file should contain processed and evaluated information about enemy units and their structure. The corresponding application program should provide the user with the capability to enter, maintain and process enemy force information and to identify those elements of the enemy not yet located or whose location data is suspect. The major EOB file entries should be: unit identification, location, subordination, status, combat activity, and combat effectiveness.

c. Filter

Filtering must be a process which should provide the capability for checking incoming ESD data for redundancy with the current data base.

d. Correlation

Correlation must be a process which should provide the capability for relating new ESD data to those existing in the database.

2. Friendly Situation Application Software

a. Unit Operations Report (UOR)

The UOR will be a process which must permit automatic record communication between the LAF and its subordinate echelons with respect to enemy activity, weather, terrain and tactical activity. Provision is to be made for entry, dissemination, storage and selected retrieval of UOR messages.

b. Task Organization (TO)

The TO file should contain information on the assignment and attachment of friendly forces. The corresponding application program should provide the Operations Subsystem personnel the capability to enter, retrieve, and modify proposed changes to the task organization. This application will also store task organization changes planned for future use and change the TO file on order. The major TO entries should be: Unit designation, type, subordination.

c. Tactical Dispositions (TD)

The TD file should contain geographic data related to combat support elements, service support locations, and certain tactical control measures. The major entries should be unit identification, location, type of location like command post, center of mass, objectives, blocking and delay ground points, boundaries, coordination lines, assembly areas, etc.

3. Applications Support Software

a. Battlefield Information Reports (BIR)

The BIR should contain the major subordinate combat maneuver elements and other designated units. The contents should include location, activity, intensity of conflict and the commander's perception of the situation. This report should be transmitted at specified intervals to LAF tactical command post.

b. Management of Intelligence Collection (MIC)

The MIC should be a function which will provide intelligence personnel with a set of files and processes to assist the collection management procedures. The following files should comprise the MIC: (1) Intelligence Collection Agent (ICA) file which will identify each collection agency and its available collection means; (2) Intelligence Collection Characteristics (ICC) file which will contain the range and degree of coverage for each collection means; (3) Intelligence Collection Requirements (ICR) file which will contain data specifying the information needed and reporting criteria; (4) Intelligence Collection Tasking (ICT) file which will identify the specific tasking requirements assigned to each agency.

c. Named Area of Interest (NAI)

The NAI should be a process which will provide users the capability of assigning a name to a geographical point, line or area (circle). This will permit the user in

future queries or searches against that area to refer to it by the given name instead of inputting several strings of coordinates. Named areas of interest will be normally established by echelons having the requirement to retrieve data on given parameters.

d. Staff Working File (SWF)

The SWF should provide the staff member-user with the capability to enter, process, store and retrieve data which does not logically fit into other SACS files. It will provide the user the ability to create new files to meet new or changing conditions.

e. Terrain File (TF)

The TF should contain terrain characteristics and the results of terrain analysis in terms of tactical evaluation, that is, critical terrain, obstacles, observation trafficability, and cover and concealment. This data will be available to all SACS users and will be graphic displays to supplement or highlight the map backgrounds. The terrain data will be provided by the topographical department. Staff members-users would add other data to supplement the file.

f. Weather File (WF)

The WF should contain weather characteristics and the results of weather analysis in terms of the weather impact on the operations. This data will be available to all SACS users and will be textual displays. The weather data will be provided by the meterological department.

g. On Line Query System (OQS)

The OQS should be a retrieval language which must provide the SACS user with the capability to define retrieval parameters and report output formats. Retrieval parameters will be specified in terms of field identifiers, relational operators, and data values. Print and display commands should specify the output media and format. The user should be able to sort the output, sum numeric quantities, count the number of records meeting search criteria, and perform periodical summaries.

h. Center to Center Communications (CCC)

The CCC process should permit correspondence between LMC central processors of dependent LAFs. Messages, summaries, and processed reports could be dispatched or requested. The requirements for passing information from the lower LAF to the higher headquarters would normally be established by directive.

4. The Training Support Software

It is logical to assume that the LAF in garrison would want to use SACS in a training capacity. To be able to accomplish training, SACS should contain a training support package which can be used to satisfy a variety of training needs like the command post exercises, component training exercises, LAF's software checkout, and operational readiness evaluations. To satisfy these needs, the training support software should contain the following items.

a. The Simulation Package

The basic design of the simulation should be able to accommodate two or more LAFs exercising in their superior LAF environment, a LAF exercising by itself, or the LAF's staff training by itself. The simulation package must permit battle simulation in a detailed event-sequenced logic and in an interactive way. This package also should provide realistic insights into the intelligence information processing and decision making on the modern battlefield.

b. The Data Reduction Program

The data reduction program should be used to screen the log tapes and extract the mission essential elements of analysis for the particular mission being conducted. Through analysis support, this data could be refined, analyzed, and assembled in appropriate feedback form for presentation to the participating staff personnel. The data reduction could be designed so as to be used during software checkout to assure operators that the operating system is performing up to specifications. Support algorithms could also be included to provide the capability of trend analysis, comparative analysis, and to measure overall system performance.

c. On-Console Training Program

The on-console training program should be loaded on SACS and used for training of the respective staff personnel in performance of their operational responsibilities. An embedded training program should also provide evaluation of

the results of the training and maintenance of training conduct records.

5. Software Distribution Matrix

The distribution matrix should permit the automatic distribution of SACS messages based on specified message characteristics. A message originator must designate the message addressees either by entering the code name for each desired addressee or by entering a single value code that represents a discrete operator-created distribution list of addressees.

AUTOMATION NEEDS-SACS EXPECTATIONS	Personnel Needs	Intelligence Needs	Operations Needs	Logistics Needs
Data Exchange	YES	YES	YES	YES
Data Management	YES	YES	YES	YES
Analysis Support	YES	YES	YES	YES
Graphics	YES	YES	YES	YES
Sensors' Interf.	NO	YES	YES	NO
War Games	NO	NO	YES	NO

Figure 2.1: Automation Needs-SACS Expectations.

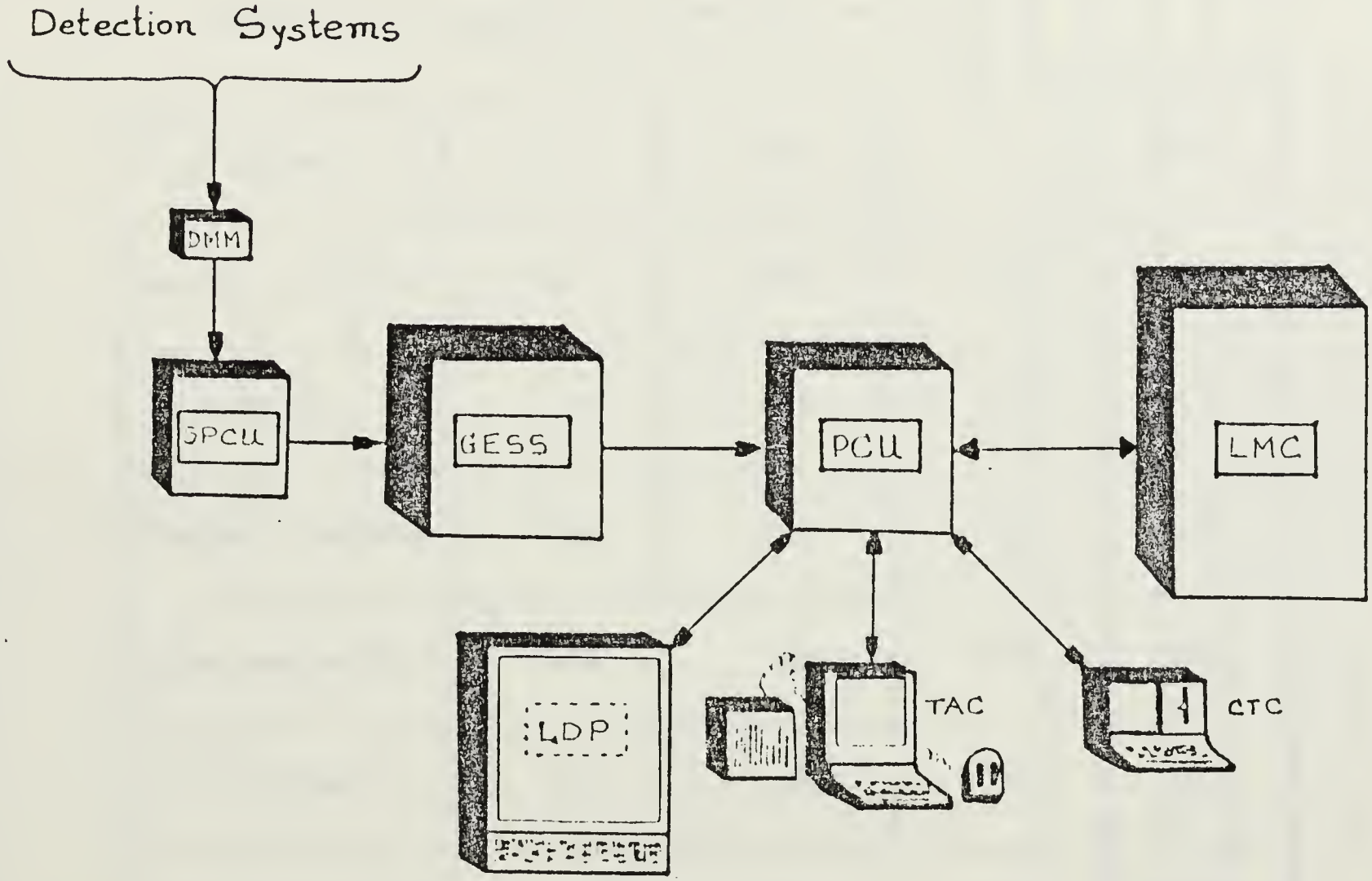


Figure 2.2: SACS HW Configuration.

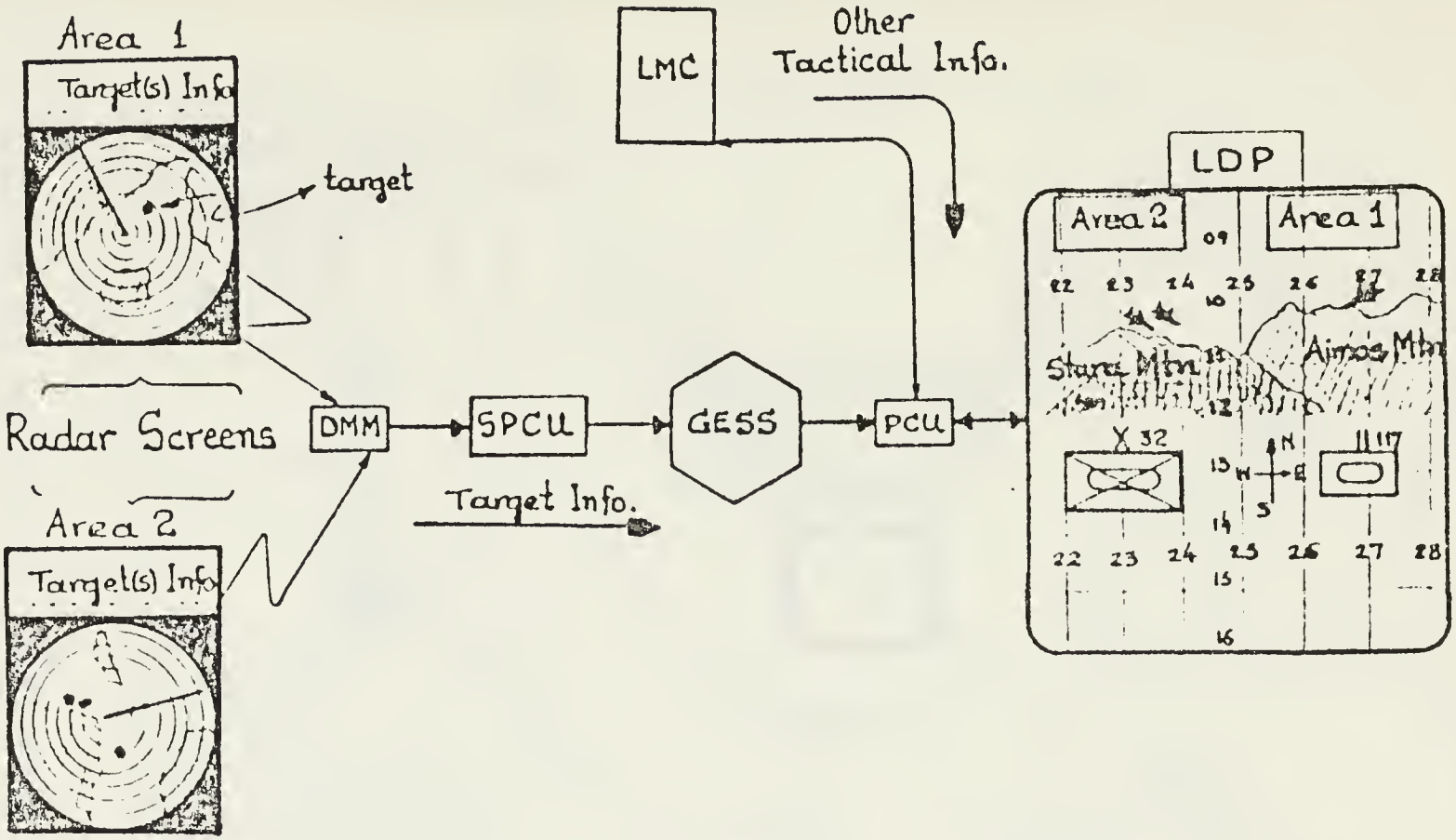


Figure 2.3: Mapping of Detection Systems on the LDP.

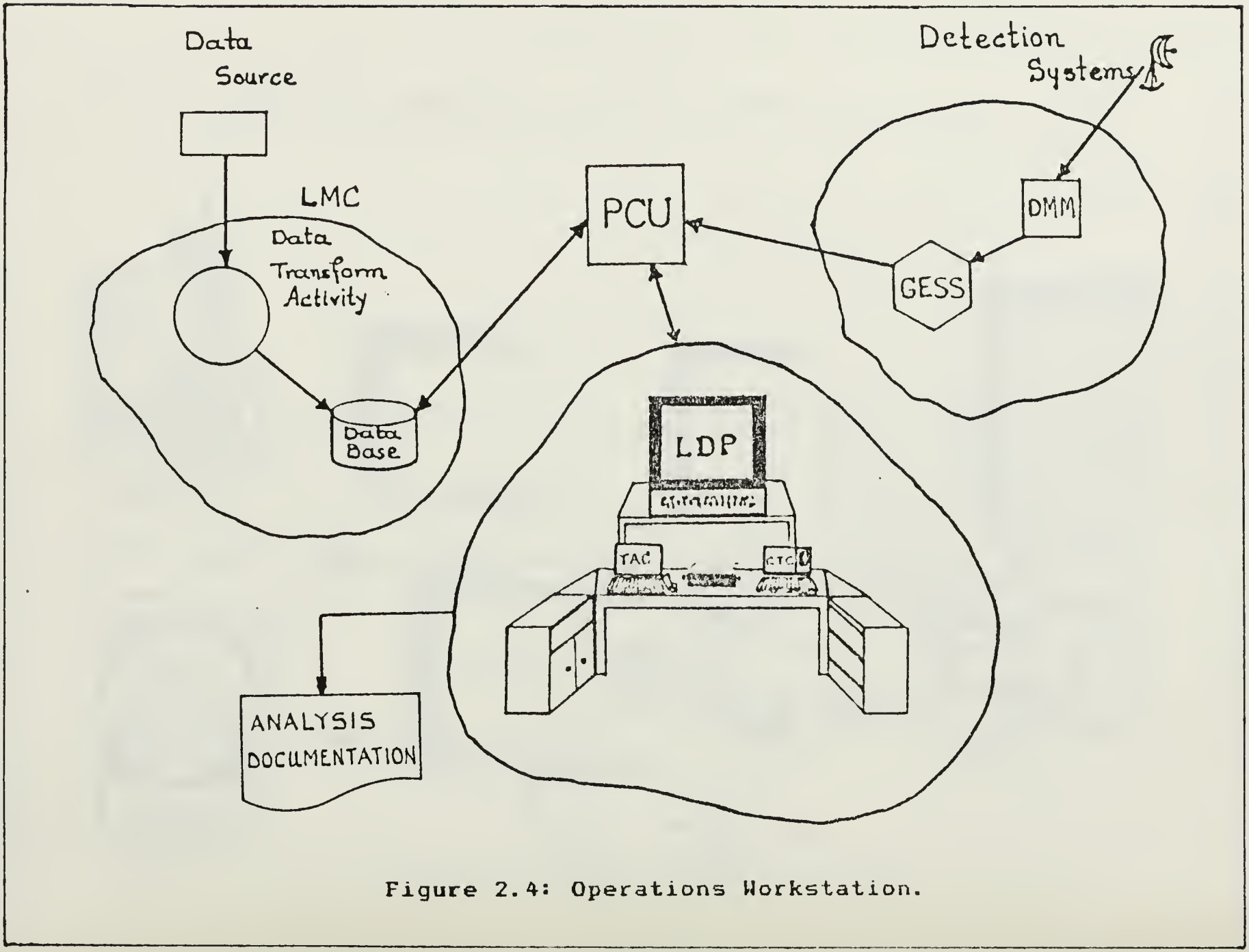
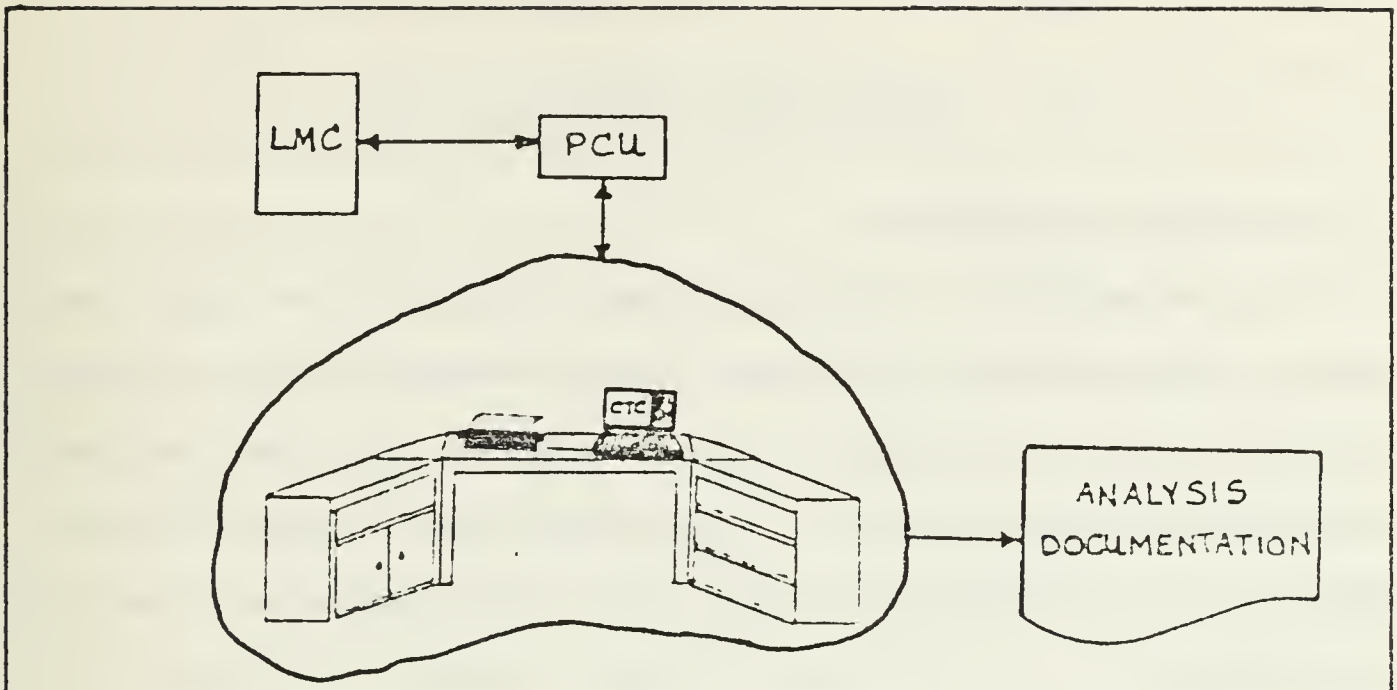


Figure 2.4: Operations Workstation.



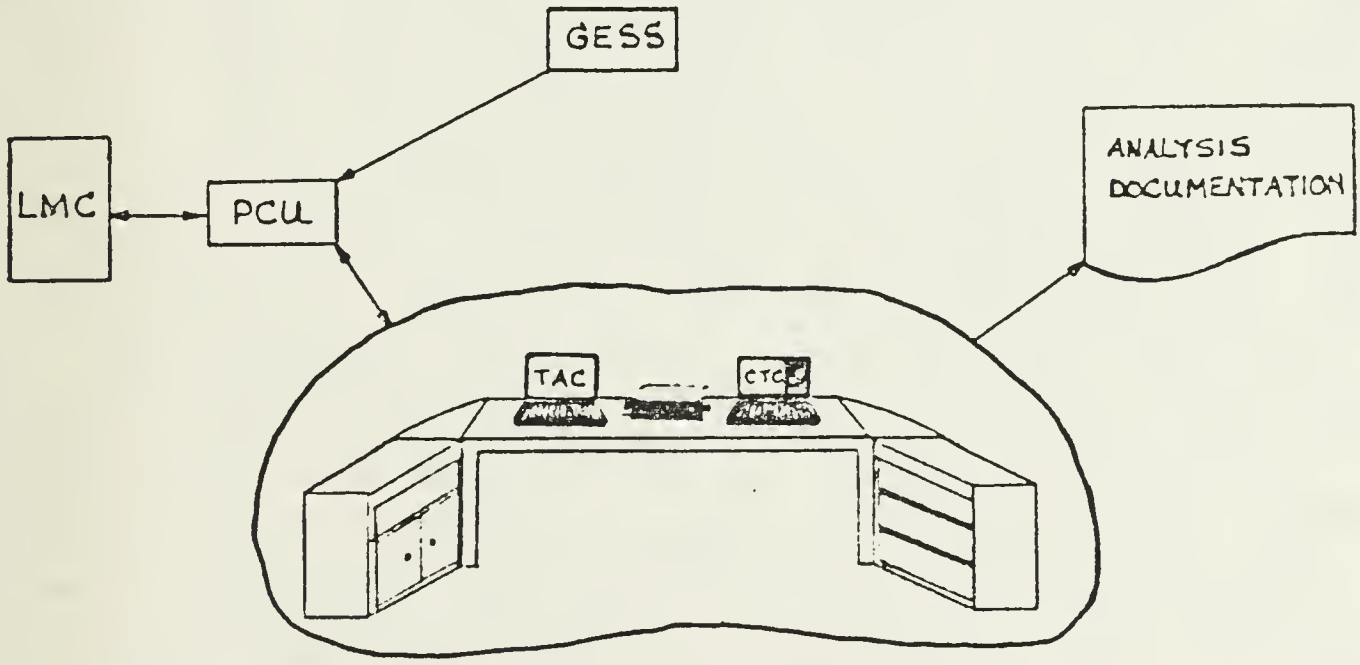


Figure 2.5: Personnel Workstation (Up).

Intelligence or Logistics Workstation (Down).

III. WORKING WITH THE SACS [1,4]

A. PERSONNEL FUNCTIONS

The personnel functions will be performed from the corresponding workstation. The basic capabilities of data exchange, data management and simple graphic displays will be available to support the function. The personnel functions will have restricted use of SACS because only a few of them are tactical in nature.

B. INTELLIGENCE FUNCTIONS

The intelligence functions will be performed from the corresponding workstation. The capabilities of data exchange, data management, analysis assistance, interface with detection systems and color graphic displays will be available to support the function. The new workstation will be used to receive combat information and intelligence messages, retrieve LMC and/or GESS graphic displays and digital data requested by the chief of staff, and to retrieve and manipulate SACS data for evaluating, analyzing and interpreting combat information. Most coordination within the LAF's comman post should be accomplished verbally or by using hard-copied outputs because this form of communication is most efficient because of the close proximity of the staff personnel. Control of the content of analysis product files should be under the intelligence subsystem to avoid confusion and possible contradictions.

Within the LAF command post the intelligence functions are performed by several staff sections. The intelligence operations functions will use SACS primarily to be on line with the current tactical situation and terrain data from the corresponding files. Also supervising intelligence dissemination, coordinating the intelligence collection assets, and determining intelligence needs will require access to LMF and GESS graphic displays and file data. Preparation of the intelligence annex and the formal staff briefings will require the creation of graphic displays as well as the gathering of current situation data. The intelligence analysis and production function will be performed using every SACS capability. SACS will be used to store combat information. Maneuver units, collection agencies and detection systems will be able to enter combat information directly into the SACS enemy situation files. The SACS features of query, filtering and correlation will be used to confirm, correlate and organize the combat intelligence into a form suitable for tactical analysis. The terrain and weather data will be used to create graphics displays showing key terrain, obstacles, observation and firing abilities, cover and concealment, accompanied with weather impact texts. This data augmented with those of the enemy order of battle, can be used to determine possible avenues of enemy approach. This data also will have utility in developing plans of action and tactical maneuvers, and for logistics subsystem in developing supplying routes and locating depots.

The enemy order of the battle analysis will be elaborated using SACS. Enemy situation data will be used for determining enemy unit identification, composition, disposition and strength. The current enemy order of the battle can be compared with the corresponding past records to determine and display unit identifications, enemy units arrangement, enemy unit disposition and enemy's course of action.

The enemy situation, order of battle and terrain files will require management. Historical records and terrain and weather features in the LAF's area that are no longer needed will be deleted. The enemy situation file can grow larger than any other file and it must be closely supervised to avoid system overloads. The necessary deletions can be automatically done, based on the criterion of age. Threshold indicators must indicate the critical file size and must initiate an automatic file pruning to maintain an acceptable file size without ignoring the usefulness and the meaningfulness of the file contents.

The intelligence reconnaissance and surveillance function will use the SACS to process requests for preplanned reconnaissance flights and to monitor the ground reconnaissance and surveillance activities.

The security functions will use SACS to receive intelligence collection tasking messages which will be translated into specific signal intelligence indicators to be used in tasking army security agency field teams. The signal security

function involves monitoring friendly non-secure communications to ascertain what information is being passed that might be of use to the enemy. SACS communications must be over secure channels which will not be subject to monitoring.

Figure 3.1 presents a gross data flow diagram for the intelligence subsystem using SACS.

C. OPERATIONS FUNCTIONS

The operations functions will be performed from the corresponding workstation. The capabilities of data exchange, data management, analysis assistance, color graphic displays and war games for training, will be available to support the function. The new workstation will be used in developing the friendly situation, unit status, tactical estimate, maneuvering forces control, and supervision of operations in compliance with the General's decisions. The overall LAF's operational status will be developed, stored and displayed and/or printed on demand. Tasks organization for supporting the maneuvering forces should be extracted, presented and reviewed as part of the operational status. The SACS database will be used to assemble an overall operations estimate for the Commanding General. The input sources for developing this estimate will be the enemy situation information as they have been filtered, evaluated, and correlated by the intelligence subsystem; the battlefield information about the friendly forces as they will be submitted in periodical reports by the subordinate echelons of the LAF; other information arriving from other friendly

sources as the superior or adjacent LAF. All this data must be logically augmented by the existing relevant database, in displays and/or hardcopies. Free text summaries must be added to explain the graphical presentations and both graphics and displays will form the operations estimate required by the General. Supportive courses of action can also be prepared and presented along with the estimate. The course of action should include: the type of action to be taken, time the action will begin, location of the action, use of the available means and purpose of the action. Changing tactical requirements needed to support the maneuvering plan, task organization, fire and engineering support will be detected by monitoring of the superior LAF networks and SACS situational displays. As tactical changes are identified, they need to be assessed in terms of criticality and developed into appropriate courses of action. Approved plans must be formed into orders, modified operations overlays, and updated SACS files necessary to implement the approved plan.

The operations subsystem tactical planners must use its workstation to develop on consoles, future courses of action to satisfy the General's guidance. Graphically developed courses of action may be assembled and stored in planning files and briefed to the General using the LDP console. Graphical and textual compositions will be invaluable in generating and storing courses of LAF's action to different tactical situations. Here it must be remembered that

unforeseen enemy action can decoordinate the LAF. The above composition will prevent such an undesirable situation and it will contribute to the stability of the system (LAF).

Operations subsystem will use its workstation to maintain the current estimate by quering and establishing information requests against the database. Assembled data can be organized graphically to demonstrate enemy and friend frontlines, boundaries of echelons, command posts and tactical maneuvering positions, barriers and obstacles, nuclear and chemical strikes.

Preplanned air support requests should be processed using the staff working file. The air support planning will be helped considerably by the displays on the LDP of the detection systems, display's graphical and textual information about the air tactical situation, giving the target itself; route, height, and speed of flight; identification of friend, foe, unknown, etc. This way the planner will have complete and precise information on how much an echelon or area suffers from enemy air force attacks, a fact which is of high importance in planning air support requests.

Figure 3.2 presents a gross data flow diagram for the operations subsystem using SACS.

D. LOGISTICS FUNCTIONS

The logistics functions will be performed from the corresponding workstation. The capabilities of data exchange, data management, analysis assistance and graphic displays will be

available to support the functions. The system graphics will be used to form the displays and hardcopies of significant logistical events for briefing the General. These displays showing obstacles, key terrain, roads, rivers, air strips, friendly and enemy unit locations, will be used to determine the main supply route and supply points. Once developed, all this information will be stored in SACS files for future reference. Area damage control, maintaining the status of supplies, vehicles, and equipment necessary for the accomplishment of the mission will be handled using SACS. Data will be gathered and organized by SACS and algorithms will be provided to perform the statistical analysis requirements of logistics.

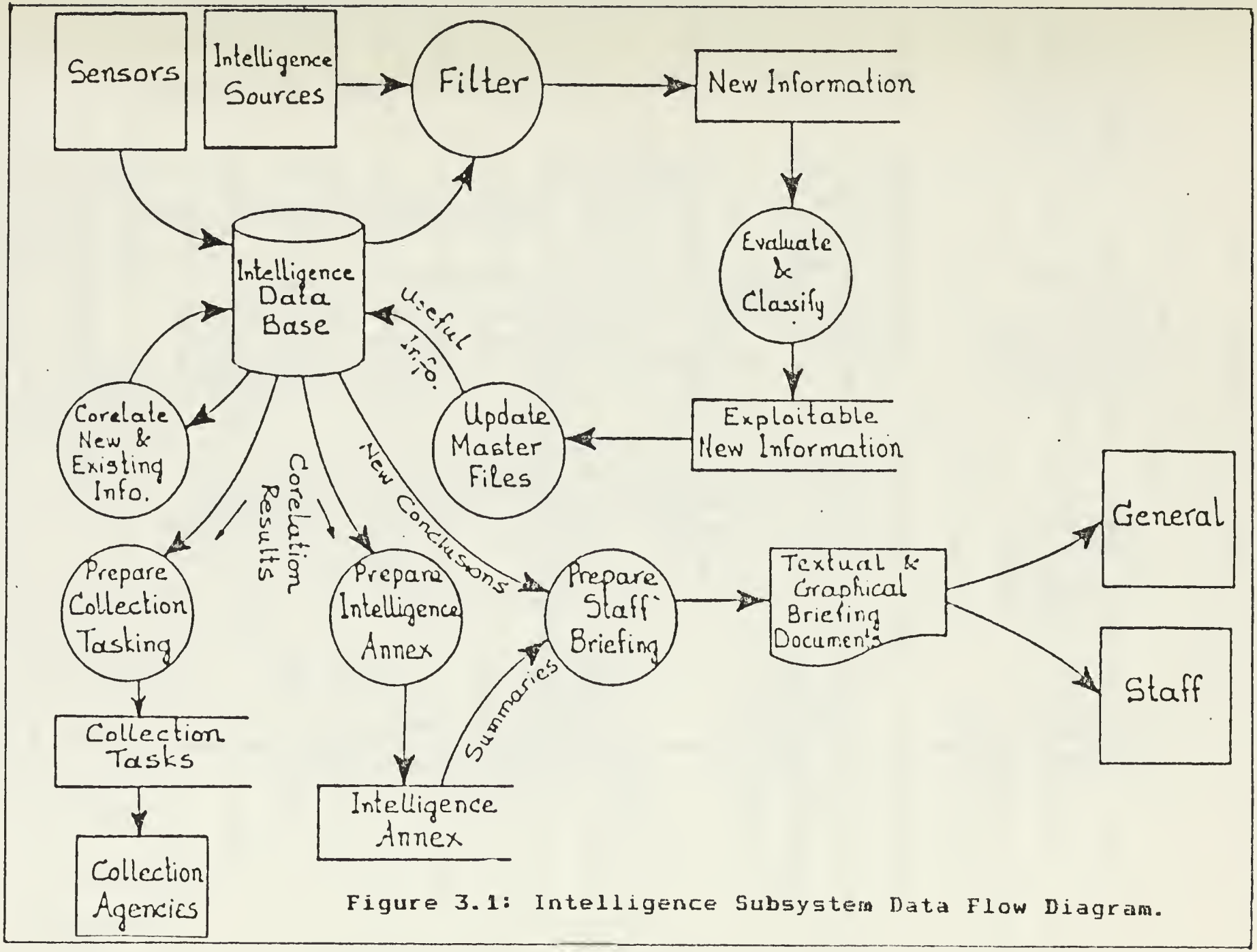


Figure 3.1: Intelligence Subsystem Data Flow Diagram.

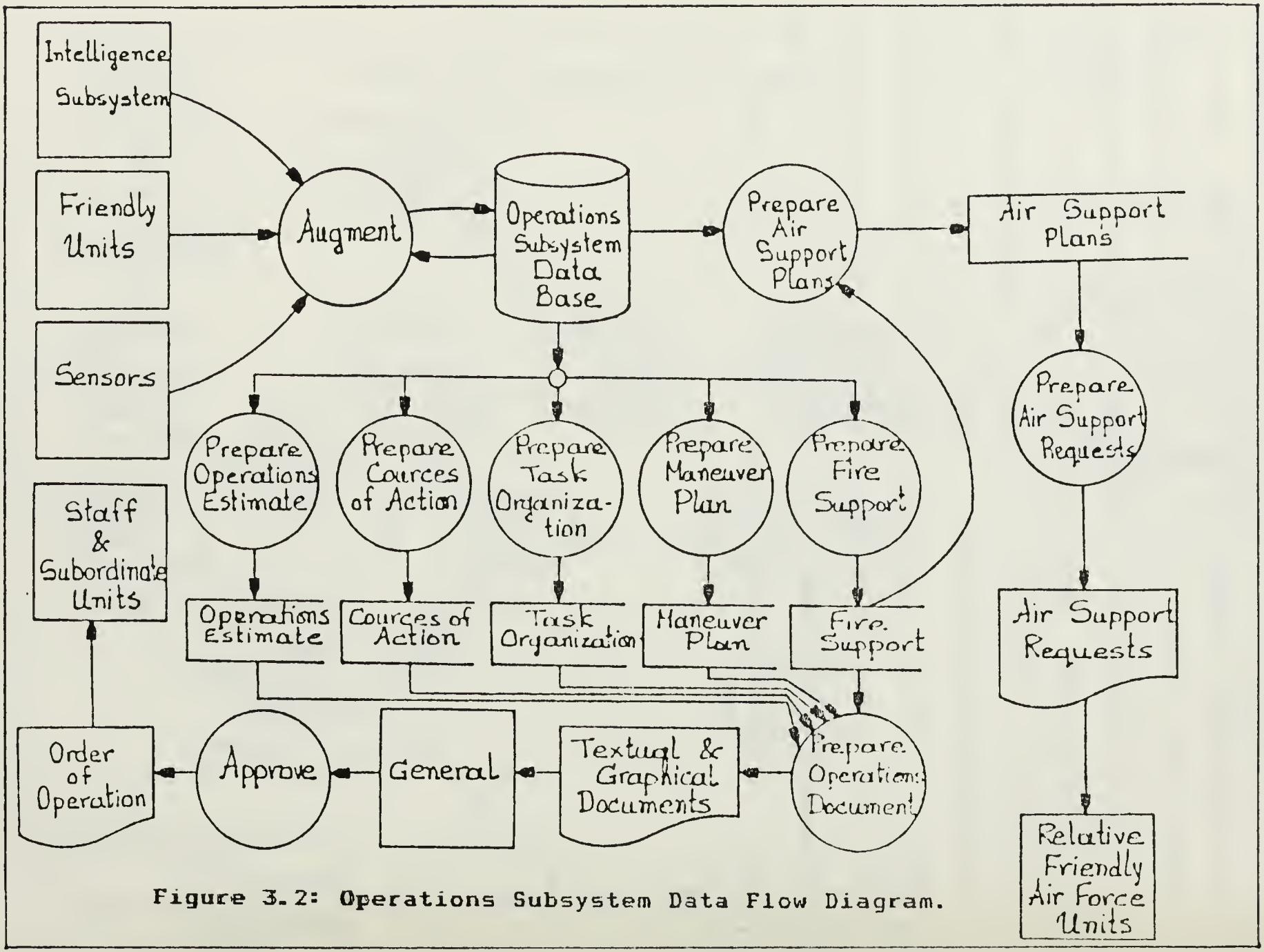


Figure 3.2: Operations Subsystem Data Flow Diagram.

IV. SECURITY AND SACS [6,7,8]

A. SACS SECURITY INTO PERSPECTIVE

Computer fraud and abuse in the private sector creates newspaper headlines since these crimes usually involve large amounts of money. But analogous crimes in a military system (e.g., SACS) may go completely undetected, even though the potential for damage to the national security is much more serious. The reason for this lack of detection is that when information is leaked electronically it does not disappear; the original remains intact and unaltered and there may be no evidence that it has been copied.

Computer systems have not been very good at keeping secrets. It is too easy to demonstrate that an opponent can penetrate the protection mechanism of typical operating systems, gain control of the machine, and obtain any information he wishes. The only reliable approach is to prevent an opponent from gaining access to the computer system. This can be typically accomplished by locking up the computers and clearing all the people who use them to the level of the most sensitive data on the machine. This approach is at least inconvenient. Operational problems occur when information cannot be made available quickly to users who need it because of too tight restrictions on access to the system. For this reason, several models of computer security have been developed in the past

which must be the milestone concepts in SACS security. These concepts are briefly discussed below.

1. Basic Security Condition

The basic security condition has to restrict a user from reading information classified above his clearance. Thus the system must keep track of the levels and compartments associated with the files used by a job during a session. Whenever a new file is created, it must be marked with the appropriate security level and all the compartments of the file used so far. Only certain authorized users will be able to access information of a corresponding classification level.

2. Access Matrix

The access matrix has to describe the system in terms of its subjects and objects. Subjects are usually processes operating at the direction of a user. Objects are files and the kinds of access that subjects may have to files. Subjects will be listed as the rows of a matrix and the objects as its columns, so each entry of the matrix tells what access a subject is allowed to an object.

3. Security Kernel

The security kernel exploits the concept of a "reference monitor" as a basis for developing a secure operating system. The reference monitor would check each reference by a subject to an object and be sure that it is authorized by the access matrix. The mechanism that handles the reference monitor has to be tamperproof, invoked on every reference, and subjected

to complete analysis and test. The security kernel of the SACS must be composed of its reference validation mechanism, access control, security-related functions and nothing else. Two axioms must govern the security kernel concept: (a) No user may read information classified above his clearance, and (b) No user may lower the classification of information (no "Read Up," no "Write Down").

B. SECURITY AND THE LIFE CYCLE OF SACS

For a developer embarking on a new project that requires a system like SACS to restrict some of its information from some of its users, there still is no approach that guarantees absolute success. To assume invulnerability of SACS as a result of a good security program is like assuming that a car will never run out of gas because it has a gas gauge. However, a good security program is a necessity and there are at least three doctrines for the SACS developer who faces the need to separate computer users with different clearances and data with different classifications. These three most significant doctrines are strongly related to the SACS life cycle.

1. Security and the Study Phase

The security requirements of the SACS must be considered together with its functional requirements. Security is not something that can be added to an existing design even though often security seems separate from function. The intelligence subsystem must, for example, deliver tactical information, and security imposes the constraint that certain

parts must not be delivered to the logistics subsystem. It is tempting to divorce the function from the constraint. Viewed at the top level, however, the requirement is for a system that delivers the intelligence information in a way that does not compromise it. Security requirements can affect the entire structure of the SACS software and thus needs to be considered at the highest level of design.

2. Security Throughout the Design and Development Phase

It is crucial to identify and state the security requirements clearly. But it is still necessary to pay close attention to the techniques used in designing and building the SACS. The functions of the SACS must be studied, focusing on the requirements for the flow of classified information, and on the conditions under which classified information is to be disclosed, modified, reclassified or to enter or leave the SACS. The first step can be a simple informal but precise model of the information flow and authority in the SACS. Such a model could help both developers and users in understanding what is to be enforced. The second step must be the use of hierarchical specifications for the design. A top level specification that will reflect the SACS structure and information flow, as well as a program specification to allow personnel to review and assess the information flow and authorization mechanisms, should be included in these hierachical specifications. The third step must be the choice of hardware that reduces security problems. Generally hardware

should provide good mechanisms for isolating different computations, simple and efficient ways to control the flow of information between isolated contexts, and a uniform way of treating different kinds of objects (e.g., SACS files). Features such as virtual memory, a device interface that offers the possibility of a uniform treatment of memory, and the ability to change addressing contexts rapidly will help in the implementation of a secure SACS. Several machine states that restrict access to critical portions of the instruction set are not required if all accesses to data are mediated by the virtual memory mechanism, but they should be used as another way of protecting critical operating system data, for example the contents of the mapping registers. The fourth step must be the choice of programming languages for which there exists a reliable and well verified compiler. The final step must be the construction of test plans with specific attention to the security requirements of the system. Testing is an important way of establishing confidence that the controls implemented are in fact effective.

3. Security and Software Engineering Techniques

Systems like SACS that must enforce military security often have a requirement that others lack. Not only must the builder and the user be satisfied with the correct functioning of the system, but it must be possible to convince the certifying agent that this is in fact the case. This consideration makes it imperative that the software be designed, implemented, and documented according to software engineering principles.

C. SURVIVABILITY OF THE SACS

One very important feature which must characterize SACS is its survivability after a possible component failure. It is easily understood how destructive the unavailability of SACS would be in a case where the tactical situation does not permit a rapid switching to the manual system. So one criterion for designing a highly secure SACS is to ensure its continued reliable operation and availability. A survivable SACS should provide for "grateful degradation;" a SACS with failed components should continue to provide service even at reduced levels. A survivable SACS should be designed so that a failed component could be taken off-line, repaired and placed back on-line, all while the system should provide uninterrupted service. One key for SACs survivability must be "redundancy." If a component fails, then an equivalent component must pick up the slack. Multiprocessing will be important in any survivable SACS. Other features which should be considered in order to achieve survivability of SACS are:

1. Incorporation of fail-safe mechanisms into the firmware rather than in software
2. Use of transparent multiprocessing; this allows performance upgrades without software modifications
3. Use of multiple input/output subsystems
4. Incorporation of major portions of the operating system into hardware
5. Incorporation of fault detection mechanisms into the hardware and software.

D. NETWORKING THE SACS WITH SECURITY

It has been stated in Chapter II that a SACS is expected to exchange data with other tactical data systems. This expectation can be met by networking the SACSs of related LAFs using the packet switching technique. The means for attaining security in the packet switched communications system is the concept of the end-to-end encryption. An end-to-end encryption is an apparent need in order to protect the exchanged information since all the exchanged messages will be out of the physical control of the communicators. In an end-to-end encryption, the sender encrypts the message and it remains encrypted while being transmitted through a network until it is received and decrypted by the receiver. A device called a PLI (private line interface) should be placed between the host LMC and the packet switches as it is shown in Figure 4.1. Figure 4.2 shows the PLI layout. The PLI will encrypt the data in each packet, leaving the header in the clear. The switches will route the packets, but the actual data will be encrypted. As a result, when packets will pass throught the switches, operators will not be able to examine the data in encrypted form nor will misrouted packets be able to divulge classified data. All the switches must be placed in military sites and can be manned by the same cleared personnel who maintain the SACS. The encryption devices will be keyed by using the same keys for a user community and different keys for other communities; in this way the communications system

will be partitioned into "communities of interest." The maintenance of the switches can be performed by the operators of the nearest SACS being interconnected. The switches themselves are computers quite small and inexpensive, and about as complicated as a peripheral controller. Since the technology and complexity is about that of a small piece of digital gear, the additional maintenance load on the SACS operators will be quite small. The PLIs can be collocated with the SACS terminals, or if multiplexers or concentrators are used, the PLIs can be placed at the access point to the switch, provided that multiplexers and concentrators are multilevel-secure and that the terminals are all secure as needed.

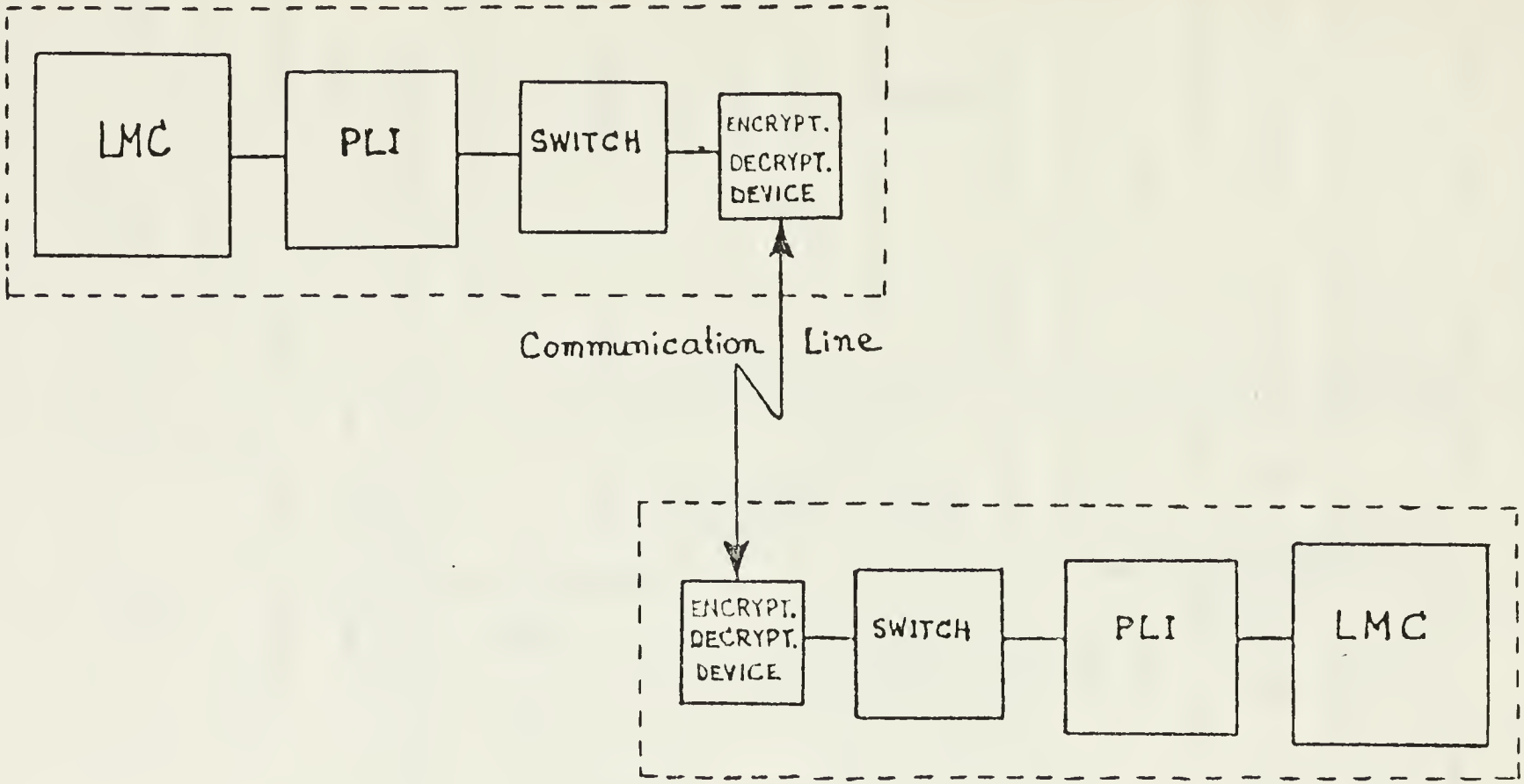


Figure 4.1: End-to-End Encryption Using PLIs

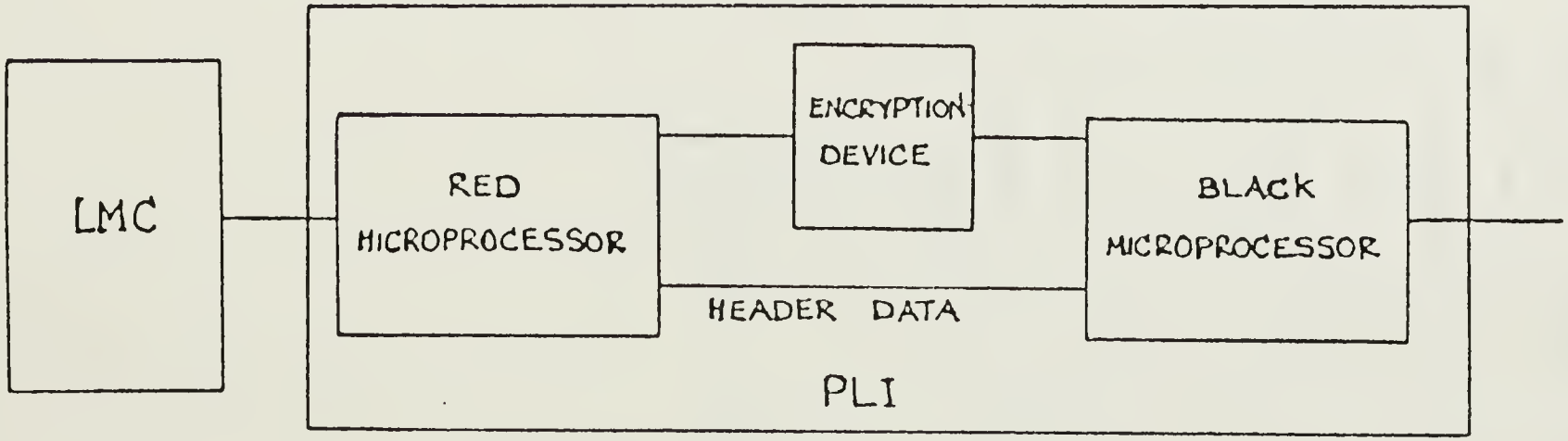


Figure 4.2: PLI Layout.

V. FACING THE END USER PROBLEM [7,9,10,11]

A. THE END USERS OF THE SACS

When SACS is introduced, it will be necessary that certain principles of automated systems should be understood by the LAF commander, staff members and other end users who will be affected by it. To a large extent success or disappointment is dependent on these end users, their involvement in the definition and logical modeling of the data, their employment of end-user database language and their acceptance of the results and the principle of shared data.

The term "end user" is used to describe someone who interacts with a computer in one way or another. This term is too broad and covers an enormous range of skills and, unless it is further qualified, may be used to describe almost anyone in the LAF that will use the SACS in some kind of data processing. It is worth listing the ways in which a person may be considered an end user.

1. The Recipient of Regular SACS-Generated Reports

Nearly everyone connected with some form of automatic data processing uses such forms. Frequently these reports are adequate to the needs of the reader. However, it is often the case that hours are wasted in performing simple analyses that could easily have been performed by the program that generated that report.

2. Application Programmers

Although there would appear to be no limit to the ability of an application programmer to obtain the desired data, this is frequently not the case. An application programmer, because of the amount of technical programming detail that must be mastered, is frequently "locked" into one system; a computer, programming language or operating system. A lack of understanding between the applications programmer and the person who uses his results is a major cause of frustration and delays.

3. Users of Interactive Database Query Languages

Such users will be the majority of the SACS' users. Their ability to extract the data they want will be limited by the power of the query language and their skill at using it. The problem is that there is no standard query language and such users may have to learn different languages--something that could be avoided. This is the main topic of this chapter. The use of a good general-purpose database query language will be of general benefit because it will be easy for naive end users to learn, and because it will provide the rapid access to data and quick writing of application programs that these users require.

B. THE QUERY LANUAGE

A mistake that is frequently made is to confuse the complexity of a language with its power. If the power of a language refers to its ability to control the hardware on which

it is run, this confusion may be justified because the current hardware is inherently complicated. However if power means the ability to provide an abstract description of a computational process, there is no reason that this should entail a language with complicated syntax or constructs. LISP and PROLOG may not be the ideal languages for end users in the LAF community, but they are among the most powerful (in the second sense) and there aren't languages with a simpler syntax.

Database access languages may be broadly divided into those that are powerful but difficult to learn, and those that are limited but easy to learn. However there is a non-procedural (so very easy to learn) query language which is quite powerful also. This is Query-By-Example (QBE) which is associated with the relational database model.

It is desirable that the staff member (being generally a naive user) approaching a terminal should be required to know as little as possible in order to get started. He may have to know a little more in order to use the subtleties of a language, but this also should be minimized. He may approach a database knowing very little about the names of the records, of fields (attributes), or how to access them. The best means of explaining the user language functions is by examples. Various psychological studies of QBE have shown that naive users acquire the skill to make complicated queries in less than three hours. The language is designed with the excellent principle that the thinking process the user follows is the same as he would

use to find the same information without a computer. Moreover, the effectiveness of QBE will never disappoint a staff member who happens to know a lot about computers and database.[5,6]

There are certain extensions of QBE like the QBPE (Query by Picture Example) that could be extremely useful for staff members if they want to create graphs with map areas such as the maneuver plans for example. Another extension of QBE is the PBE (Procedures by Example) which covers a wide area of SACS applications. QBPE is based on an integrated database system interfaced with an image analysis system. By using pattern recognition and image processing manipulation functions, pictorial descriptions can be extracted from images. These extracted descriptions and inherent registrations of pictures are then integrated into a relational database; the original two-dimensional pictures are kept in a separate picture store. Thus, queries concerning pictures can be manipulated through the relational database, eliminating the need to process vast amounts of imagery data. If a user's request can be expressed in terms of the extracted picture descriptions, there is no need to retrieve and process the original pictures. If, on the other hand, the stored information is not sufficient, all pictures satisfying selection criteria can

---

[5] J. Ullman in his book Data Base Principles, CSP 1982, pp. 207-208, proves the power of QBE.

[6] J. Martin, in his book An End User Guide to Data Base, 1983, pp. 99-101, presents 170 lines of a COBOL program for an inquiry that can be handled with one screen by QBE.

be retrieved from the picture store and processed until the required precision is obtained. Figure 5.1 presents the data-flow diagram of the QBPE background. Using QBPE is the SACS, most queries could be specified from relations which will be parts of a database comprised of land images and digitized maps. In Office Procedures by Example (OPBE) there are primarily four major components beyond the QBE database management system, some of which are generalizations of the QBE facilities.

1. Generalized Data Objects

Whereas the fundamental data object in QBE is a table, in OPBE the objects are forms, reports, charts and documents, all of which can be created, edited and sent to other nodes of the system.

2. Communication Subsystem

In order to communicate in the form of the above described objects to various nodes of the system (such as the related LAFs being connected through a network), we must have a communication subsystem. For each node of the network there exists a local database with the ability to access centrally shared databases.

3. Triggers

A basic necessity in any office automation is the ability of the system to take automatic actions whenever certain conditions, times or events are met. In doing so the user can automate much of the routine procedures, thus devoting

his time to more advanced tasks. The following are some actions that we may want to automate:

- Deferring of certain messages
- Creation of various logs
- Automatic inventory replenishment requests
- Follow-up procedures (for example if an answer is not received within 2 hours, the user will be alerted).

Complicated boolean and arithmetic operations can be formulated using the condition boxes of the OPBE & OBPE. The text processing in the OPBE is harder than that of incorporating arithmetic. This problem can be solved by a good interface between the QBE and a suitably structured editor.

At the level of the user interface QBE is extremely well engineered, exploiting color graphics and screen control for ease of data entry. It leaves the user in no doubt about the data model (relational) that is in use; relations are visible tables. The programming environment, the means by which data and queries are stored and recalled, is also extremely well thought out.

C. THREE PROBLEM SOLVING SCENARIOS

To show the utilization of the user communication interface in intelligence production, three trivial examples of using QBE and its extensions, are presented. The intention of the examples is to demonstrate to the staff members a typical

interaction session rather than to present truly valid algorithms for the corresponding procedures.

1. Identification of Missiles in a Firing Event

The hypothetical problem of the missile event can be described as:

a. Identify the missile as a known configuration

b. Identify the missile as a new system

c. Produce a report of the parameters of the event.

The data available about the event include:

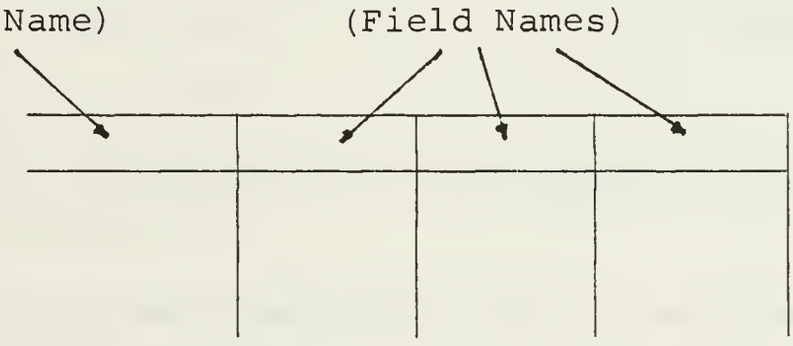
a. Launch Site: Rplace, USSR Missile Launch Facility

b. RV Impact: Gplace, Greece

c. 2 stage ignition:

- Altitude = 30 km over Bplace, Bulgaria
- Time = .4 hours

The user sitting at the terminal is presented with a skeleton of a table on the screen:



(1)

The user knows that there is a "MISSILE" record and he wants to know what field exists in that record. So he types:

MISSILE P.			

(2)

"P." stands for "Print." The terminal may respond increasing the number of columns as necessary:

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS

(3)

The user wants to know what missiles have two ignition stages, so he types:

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
	P.	P.	2	P.	P.

(4)

The values of the fields are then listed in the corresponding columns:

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
		H101		4500 km	17 km
	SRBM	H101J	2	4000 km	17 km
		D4		2000 km	14 km
		D5		1500 km	12 km
		DDEO		1000 km	7 km

(5)

The user knows from his maps that the distance between Rplace and Gplace is 1500 km. So the information obtained so far is not enough since (5) gave four types of missiles of two ignition stages that could strike Gplace. It is clear that the user's query to identify the missile cannot be answered by reference to one type of record. With QBE he can display

two or more different skeletons on the screen at once. He fills in both of them and then presses the ENTER key (or equivalent) indicating that this is one entry. In our example, knowing the 2nd ignition altitude and time, he can call a second record having the trajectory elements of the missiles. Thus he combines the two records as follows:

TRAJECTORY	MTYPE	TTYPE	STAGE	ALTITUDE	TIME
	X		2	30 km	.4 h

(6)

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
	P.	X P.	2	P.	P.

The terminal will respond:

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
	SRBM[7]	D4	2	2000 km	14 km

(7)

Now the user's query has been answered after following a very simple procedure.

Suppose that instead of (5), we had the (5') listing:

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
	NULL	NULL	2	NULL	NULL

(5')

[7]SRBM = Short Range Ballistic Missile

In this case the user could insert the new system as follows:

TRAJECTORY	MTYPE	TTYPE	STAGE	ALTITUDE	TIME
I.	NEW	?	2	30 km	.4 h

(6')

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
I.	UNKNOWN	NEW	2	1500+	?

"I." is used for insertions. In this last case, the user inserts the data he has with respect to this new system. In the columns, he has no data, so he inserts the words "UNKNOWN," "NEW," "1500+," "?." When he obtains additional information he can update the records as follows ("U." is used for update).

TRAJECTORY	MTYPE	TTYPE	STAGE	ALTITUDE	TIME
U.	D4	PARABOLA	2	30 km	.4 h

(7')

MISSILE	CLASS	TYPE	STAGE	RANGE	RADIUS
U.	SRBM	D4	2	2000 km	14 km

Using QBE the user can also delete data ("D."), link tables, retrieve data under conditions specified by him. The database administrator can assign authorizations to certain users and he can also impose constraints. These control and integrity features of QBE are very desirable in the SACS case, and they

can be elaborated in accordance with the SACS security general fame.

2. Creation of a Graph of the LAF's Vital Area

The TAC using the QBPE facilities can read its color map background which can be stored in a digital form in a separate picture store. Most queries would be specified from the following relations:[8]

```
CITIES (FRAME,CITY-1D,X1,X2,Y1,Y2)
CITYNAME (FRAME,CITY-1D,NAME)
ROAD (FRAME, RO-1D, XA,XB,YA,YB)
RO-NAME (FRAME,RO-1D,NAME)
MOUNTAIN (FRAME,MOUN-1D,XM1,XM2,XM3,XM4,YM1,YM2,YM3,YM4)
    :
```

etc. including all the necessary information for the production land features. X and Y describe the required corresponding 2D coordinates. The "FRAME" is represented by a number that corresponds to a certain portion of the original map image.

Suppose the user wants to sketch the vital area within certain boundaries specified by the land features. This query can be formulated as follows:

MOUNTAIN	FRAME	MOUN-1D	NAME
	2	04	OLYMPOS
	3	09	OSSA
	7	23	AIMOS

(8)

[8] For a complete analysis of the concept, see: "Picture Query Languages for Pictorial DB Systems," by N.S. Chang and K.S. Fu, Computer, November 1981, pp. 23-33.

MOUNTAIN	FRAME	MOUN-1D	XM1	XM2	XM3	XM4	YM1	YM2	YM3	YM4
	2	04	a	g	q	i	d	l	u	x
	3	09	b	h	r	j	e	m	v	y
	7	23	c	k	s	o	f	n	w	z

(9)

The system will respond with an intermediate result table for all the boundary segments of the vital area:

R1	X1	Y1	...	XN	YN
	X	Y	...	Z	W

(10)

The user wants to draw the roads which are in the vital area:

ROAD	FRAME	RO-1D	NAME
	2	12	ETHNIKI
	3	15	EGNATIA
	4	63	LARISSAS

(11)

The command "S." stands for "Sketch" so the user will type "S." in (10) and (11) as follows:

R1	X1	Y1	...	XN	YN
S.	X	Y	...	Z	W

ROAD	FRAME	RO-1D	NAME
S.	2	12	ETHNIKI
	3	15	EGNATIA
	4	63	LARISSAS

The system will respond presenting on the screen the sketch-picture of the vital area with the specified roads. The user could ask for the drawing of the rivers, hills etc., according to his need. The user exploiting the other graphic capabilities of the TAC can enrich his sketch by drawing friendly and enemy dispositions, avenues of approach, points of interest, etc., and by adding textual explanations for his reports.

Currently the pictorial operators used to contrast pictorial entities are as listed below:

- Pictorial Union of two given regions: UNION-R1R2
- Pictorial Intersection of two given regions: INT-R1R2
- Compute the length of a given line: LENGTH-L
- Compute the perimeter of a given region: LENGTH-R
- Compute the area of a given region: AREA-R

These operators are intended to construct only the basic relations among points, lines and regions for queries concerning pictorial information. Depending on the application requirements, user-supplied operators can be implemented for more efficient operation.

3. Sending A Message to the Superior LAF/G3

Suppose that the G3 of our LAF wants to send the maneuvering plan for approval to the superior LAF. This can be done using the capabilities of OPBE[9] as follows.

---

[9] See "A Language for Office & Business Automation" by M. Zloof, Office Automation Conference Digest, March, 1980, pp. 240-260.

UNIT	NAME	LOCATION	SENDER
	G3	L	

A

NAME: G3
LOCATION: L
Subject: Maneuvering Plan

- - - -

communication concepts, they will quickly perceive the advantages of SACS; nearly all the information resources they might require are readily available from their work station. They will be able to retrieve documents that relate to their job and insert relevant analysis products in their reports. They will be able to generate messages and on-line reports for those who need to use the results of their work. They will have convenient facilities for presenting and routing on-line requirements for additional information collection.

Whereas the staff member will be in the beginning mildly amazed with the versatility he has observed in the workstation equipment, he will soon experience the potential of the new horizons offered by a friendly, trustworthy and obedient SACS for carrying on his tasks.

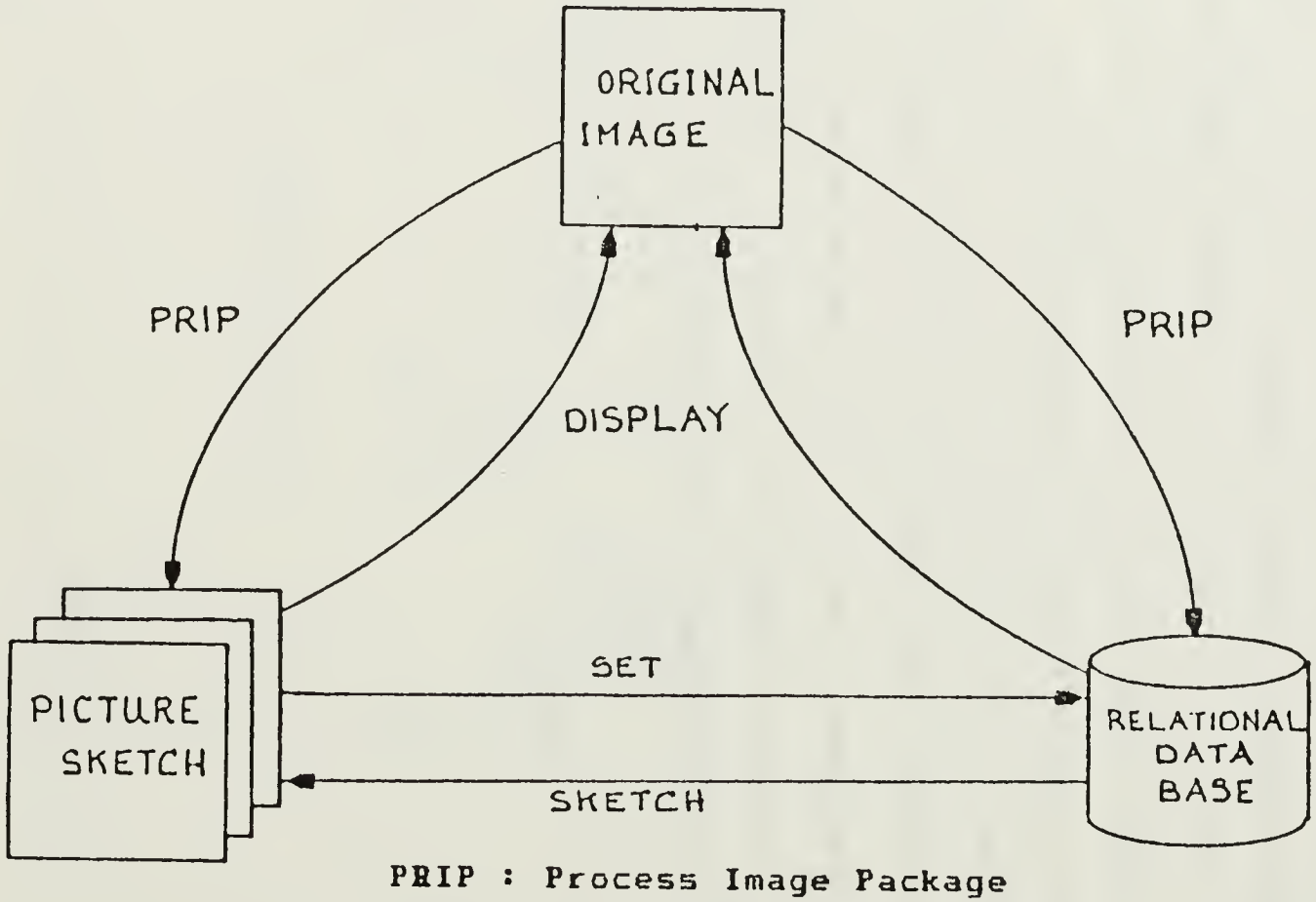


Figure 5.1: Data Flow Diagram of QBPE.

VI. INTELLIGENCE INFERENCE AND DECISION MAKING [13]

A. THE MILITARY INTELLIGENCE PROBLEM

It is clear that every staff activity in the LAF is exclusively based on the intelligence subsystem during the war time. The operations and logistics plans are formed using the timely evaluated information about the enemy's location, strength, capability, vulnerability and intentions. If this information is accurate then we can make good, more or less, plans. But if the information we have is not accurate enough, then it is not possible to make good plans and good decisions, no matter how good staff officers or inspired leaders that we have. The old characterization of Clausewitz seems to still be appropriate: "...a great part of the information obtained in war is contradictory, a greater part is false, and by far the greatest part somewhat doubtful." Modern improvements in intelligence sensors have almost embarrassingly exploded the amount of data collected, but the information is still enormously variable--mainly because this advance in sensor technology has been countered by enemy concealment and deception sophistication. The intelligence expert cannot know the location, activity and intention of every unit in the enemy army, but if enough is located the rest must be inferred. The theoretical question is--how much he has to know to be able to infer the rest?

A LAF has many sources of data. There are the forward units, observers, and patrols reporting enemy type, activity and strength. Prisoner interrogation and agents are another source. There are radio intercepts, visual, magnetic-acoustic and radar sensors associated with all LAFs. The use of aircraft, overflying the enemy, generates another avalanche of data. The intelligence analyst must look for signals in the presence of noise or deception. Camouflage netting for example tends to obscure the size, shape and color of covered objects from visual observation. The analyst must expand his examination to consider reports of other activities that may be germane to the event of interest. A report of an armored brigade in the area, for example, might give support to the belief that an object under camouflage is a tank. There is the occurrence of frequent transformation between the detection of any event and the final assessment. Figure 6.1 presents this sequence. The first transformation ($P_{d,n}$) occurs as some sensor detects physical stimuli received from a special characteristic of the target. The second transformation (P_c) takes place as the interpreter perceiving the size and shape may report possibly one armored vehicle. The third transformation (P_s) may identify it as a tank; the fourth (P_i) the model and type of tanks in the force. The fifth (P_{i+1}) transformation might be the identification of the force as the "X" Armored Division commanded by General "Y". If the enemy strategically places tank silhouettes to give

the illusion that tanks are present, a whole series of errors can result. On the other hand, the expansion of the probability trees for the enormous numbers of events we will have from the sensors will make the use of SACS a brute force approach, inevitably prone to combinatorial explosion if methodologies are not applied to establish the basis for the design of an appropriate data processing system for military intelligence purposes. Thus the objective of this chapter is to develop some mathematical models that:

- Can minimize the harmful effects of incomplete and unreliable data.
- Can facilitate the information inference from the existing data.
- Can be the basis of further research for a better simulation of the intelligence problems.

B. THE TACTICAL INTELLIGENCE MODEL

Suppose there is a critical flank which must be held. Let X and Y represent the level of forces on each side. The value of X should be proportional to the value of Y since this is imposed by the tactic doctrines. In addition, the change of X force, because of casualties, is proportional to the absolute size of the opposing force. These relations can be expressed by the following equations:

$$X = k_1 Y$$

$$X' = k_2 Y$$

If we add these equations we'll have:

$$X + X' = (k_1 + k_2) \cdot Y$$

If we say that $k_1 + k_2 = k$, then:

$$X + X' = k \cdot Y \quad \text{or}$$

$$X' = k \cdot Y - X$$

This equation assumes perfect information of X about Y. If X is not sure of Y force level and has to estimate or infer from intelligence (this is often the case), this equation can still be used by using estimate terms involving the mean (μ) and variance (σ)

$$X\text{'s estimate} = Y_e(\mu_y, \sigma_y)$$

Then

$$X' = k \cdot [Y_e(\mu_y, \sigma_y)] - X$$

We can go further and enrich the equations with factors of land morphology, weather impact, etc., in order to make a more representative model. Finally the general form of this equation will be:

$$X' = f(X, Y, Z, \ldots)$$

We can write a FORTRAN program to find approximate solution to this first order differential equation with initial condition X (Y = 0) = 0, using Euler's method. Euler's method assumes that during the interval [Y,Y+ΔY), X' remains constant and that

$$\Delta X/\Delta Y = X' = f(X,Y) \rightarrow$$

$$\rightarrow \Delta X = \Delta Y \cdot f(X,Y).$$

Thus

$$X_{New} = X_{Old} + \Delta X = X_{Old} + \Delta Y \cdot f(X_{Old}, Y_{Old})$$

Or stating this as a difference equation:

$$X_{i+1} = X_i + \Delta Y \cdot (X_i, Y_i) \qquad (1)$$

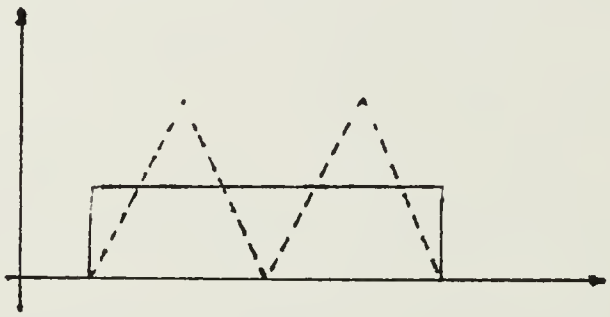
for i = 0,1,...,N. The FORTRAN program is:

```
      READ N, DELTAY, Y, X
      PRINT, X,Y
      DO 10 I = 1,N
      Y = Y + DELTAY
   C  Use equation (1)
      X = X + DELTAY * F(X,Y)
      PRINT, X,Y
  10  CONTINUE
      STOP
      END
```

The change of Y in discrete units 1,...,N expresses the reinforcements of Y in terms of, say, battalions. Of course F(X,Y) = f(X,Y) must be defined in a FUNCTION subprogram.

For a fixed value of Y_i we can have an error which increases as ΔY increases and is of the order of $(\Delta Y)^2$.

It must be stated here that there is a bias against μ and σ for this kind of problems. In the following picture, the solid and dotted distribution have the same μ and σ. However there is a question if they would be treated the same.



In addition, another question, equally reasonable, is how representative are monotonic functions in expressing the dynamics of the critical flank. In any case this model is very tractable analytically and there are a lot of things that could be done in this vein.

C. THE TARGET DETECTION MODEL

Suppose we detected a group of enemy targets with a low resolution radar sensor. The display shows just "blobs." The question is, "Are they tanks or artillery, or some mixture of both?" We decide to make four trials with another high resolution sensor to identify each one of the four "blobs." If our awareness or indifference is such that it is equally likely that they are tanks or artillery, Figure 6.2 shows there are 16 possible outcomes to the four trials.

Suppose the results of the first three independent trials were "tank, artillery, tank." To the question, "What is the possibility that the fourth try is a tank?", the answer is 1/2. In other words, by considering the permutations of trials as the probability space, we can't learn anything. Instead of this from our knowledge of the enemy's organization, we can express our indifference by equal likelihood in terms of distributions, namely, that it could be eitehr 100% tanks, 75% tanks, 50% tanks- 25% tanks or 0% tanks, and make them equal in probability (Figure 6.3). Now if our experience on the first three trials was "tank, artillery, tank" then the probability of the fourth trial being a tank is 3/5 = .6. In other words, if we condition the probability space through the use of distribution of ratios, we learn more.

D. THE "TWO LOOKS" MODEL

The previous model assumes that there is a final sensor which makes the identification of tank and artillery decisive and correct. This is not usually the case. It is often necessary in identifying a target to make repeated trials and combine ancillary data with detection data. We can set up a decision theory model which will give us probabilistic limits involved in looking at the same target with multiple sensors. The question is, "What is the payoff for multiple sensors?", or, "If we make repeated trials with low quality sensors, do we in fact gain?" Or, "Shall we define a detection as the union of two sensors or the intersection of two sensors?"

The analysis would be:

Let

p = "a priori" probability that a target is in the area

P_d = Probability to detect a target given that the target is present

P_n = Probability to detect a target given that the target is not present.

Then the probability of making a right decision is given by the equation:

$$P_R = P_d \cdot p + (1 - P_n)(1 - p) ,$$

and the probability of making a wrong decision:

$$P_W = 1 - P_R = (1 - P_d) \cdot p + (1 - p) \cdot P_n$$

If L_1 is the loss associated with a Type I error ($\alpha = (1 - P_d) \cdot p$) and L_2 is the loss associated with a Type II error ($\beta = (1 - p) \cdot P_n$), the expected loss for a wrong decision is

$$E(L) = \alpha \cdot L_1 + \beta \cdot L_2$$

Let's start with the assumption that the target is detected if it is detected with either sensor A or sensor B or both, that is ($A \cup B$). The improvement "I" can be defined as in Figure 6.5, which in percentage terms becomes:

$$I[(A \cup B),A] = 100 \times \frac{P(1-P_d(A))\cdot P_d(B)\cdot L_1 - (1-p)P_n(B)(1-P_n(A)\cdot L_2}{p(1-P_d(A))\cdot L_1 + (1-p)P_n(A)\cdot L_2}$$

Let's now quantify a question that often arises. Suppose we suspect that there is a target in the data batch from the sensors. The sensor being used has a fairly low probability of catching it. How much do we gain by adding a second sensor also of low catching probability? Assuming that $P_d(A) = P_d(B) = P_d$ and that $P_n(A) = P_n(B) = P_n$, we have:

$$I[(A \cup B),A] = 100 \times \frac{p(1-P_d)\cdot P_d\cdot L_1 - (1-p)P_n(1-P_n)\cdot L_2}{p(1-P_d)\cdot L_1 + (1-p)\cdot P_n\cdot L_2}$$

Assuming also that $P_n = .3$, $L_1 = 50$, $L_2 = 10$, $p \in [.1,19]$, and $P_d \in [.1,19]$, we can have some sample curves with a simple BASIC program (see Appendix A). Two looks are not always better than one. We could require that both trials A and B ($A \cup B$) detect a target before a target is said to have been detected. Such a procedure would decrease the number of false alarms at the cost of missing more targets.

If detection by both A and B ($A \cap B$) is required, then

$$P_d(A \cap B) = P_d(A) \cdot P_d(B) \quad \text{and}$$

$$P_n(A \cap B) = P_n(A) \cdot P_n(B)$$

The equation for the expected loss from a wrong decision is:

$$E(L(A \cap B)) = p(1-P_d(A)P_d(B))\cdot L_1 + (1-p)P_n(A)P_n(B)\cdot L_2$$

The equation of improvement is

$$I[(A \cap B),A] = (E(L(A) - E(L(A \cap B)))/E(L(A))$$

or

$$I = 100 \times \frac{p\cdot P_d(A)(1-P_d(B))\cdot L_1+(1-p)P_n(A)(1-P_n(B))\cdot L_2}{p(L-P_d(A))\cdot L_1+(1-p)P_n(A)\cdot L_2}$$

Again for a range of reasonable values of p, P_d, P_n, L_1 and L_2, we can have some sample curves that show that in any case we have improvement detecting by both A and B sensors. The possibilities of using three or four trial combinations using the intersection concept is obvious.

E. THE "WHAT THE ENEMY IS GOING TO DO" MODEL

If whether the enemy will cross, for example, a river is a possibility whether or not it is true, can be regarded as hypotheses and the data from the intelligence subsystem can be related to the hypothesis. In a simple example, we can make the following formalism:

H = hypothesis that the enemy will cross the river

H' = hypothesis that the enemy will not cross the river

D = data from the intelligence subsystem

B = the intelligence background

$P(H|B)$ = probability assigned to the truth of H given the truth of B

$P(H|D,B)$ = probability assigned to the truth of H given the truth of D and B

$P(D|H,B)$ = probability assigned to the truth of D given the truth of H and B.

Now we want an expression for $P(H|D,B)$ in terms of H, D, B and H' because we want to accept, reject, or modify the hypothesis in light of the data from the field under different states of knowledge. This expression will be a Bayes equation:

$$P(H|D,B) = \frac{P(D|H,B)*P(H|B)}{P(D|H,B)*P(D|B) + P(D|H',B)*P(H'|B)}$$

In order to make the scenario more realistic, let us assign the following concrete meanings of the above formalism.

$P(H|B)$ = the analyst's assignment of probability to H after reviewing the background B

$P(H'|B)$ = the analyst's assignment of probability to H' after reviewing the background B

$P(H|D,B)$ = the probability of H after data from the field

$P(D|H,B)$ = the probability assigned to the truth of the data from the field, assuming the truth of H and B

$P(D|H',B)$ = the probability assigned to the truth of data from the field assuming that B is true and H is false or H' is true.

Now we want to know whether $P(H|D,B)$ goes to "0" or to "1" or stays unchagned. In other words, we want $P(H|D,B)$ to move

to "0" or to "1". This is because, if I have a hypothesis that doesn't move, I had better set up another more sensitive hypothesis. To make this point of view clearer, by diving the right side of Bayes' equation through by the numerator, we have:

$$P(H|D,B) = \frac{1}{1 + \frac{P(D|H',B)*P(H'|B)}{P(D|H,B)*P(H|B)}}$$

or

$$P(H|D,B) = \frac{1}{1 + \frac{P(D|H',B)*(1-P(H|B))}{P(D|H,B)*P(H|B)}}$$

Dividing this ratio through by $P(D|H',B)$ we have:

$$P = \frac{1}{1 + \frac{\frac{1 - P(H|B)}{P(D|H,B)*P(H|B)}}{P(D|H',B)}}$$

That is, if H is in question, then:

$$P(H|D,B) = f(\frac{P(D|H,B)}{P(D|H',B)})$$

This is an equation of low resolving power, but in the context of this point of view, two issues can be made clearer:

1. Suppose we developed the hypothesis, but the background was such that $P(H|B)$ was only 1/2. The question is: "How can I get my hypothesis closer to certainty ("1") or to uncertainty ("0")?" Say that $P(H|D,B) = .8$. If I solve the

preceding equation, the ratio $P(D|H,B)/P(D|H',B)$ must be equal to 4. This means the data from the field D must be 4*B truer on H than it is on H', in light of the intelligence background B. It is clear from this that a prudent indifferent hypothesis must collect a lot of critical experimental data.

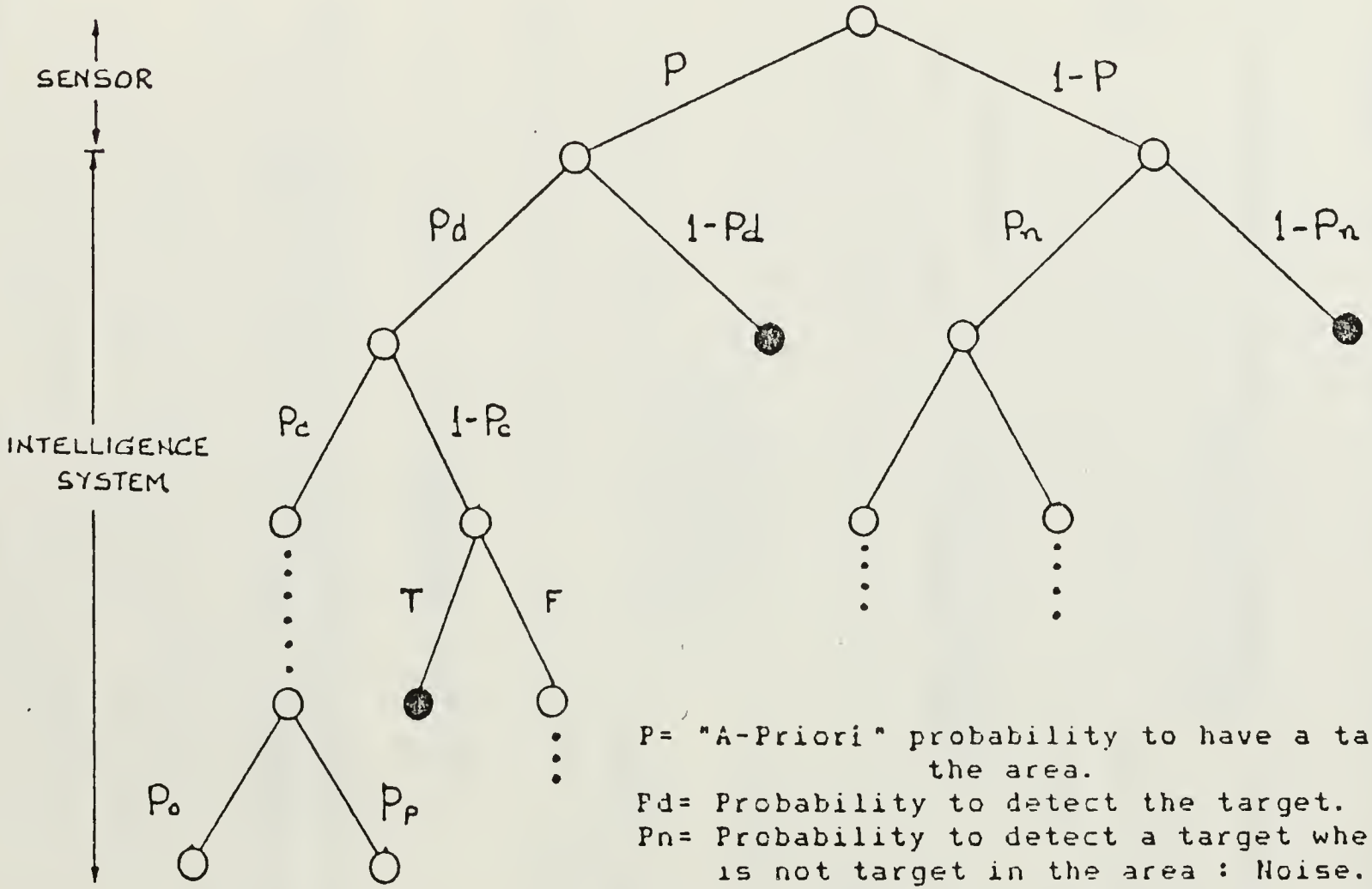
2. An equivalent but perhaps more graphic illustration can be set up this way: Suppose $P(H|B) = .8$, which means we are pretty sure from B that the enemy will cross the river. After we get the data from the field, we find that $P(D|H,B) = .5$, and $P(D|H',B) = .5$, which might mean that the reports can't be preferentially assigned to H or H', considering the background B. Then

$$P(H|D,B) = \frac{1}{1 + \frac{(1 - .8)/.5}{.5*.8}} = .8$$

As common sense suggests, there can be no change between $P(H|B)$ and $P(H|D,B)$ when

$$P(D|H,B) = P(D|H',B)$$

but we can also argue that if the data from the field cannot change a prior hypothesis, there is in effect no learning from the data.



P= "A-Priori" probability to have a target in the area.
Pd= Probability to detect the target.
Pn= Probability to detect a target when there is not target in the area : Noise.
Pc= Probability to categorize the target vs decoy.
Po= Probability for complete identification of the target.
Pp= Probability for partial identification.

Figure 6.1: Transition Probability Tree.

		t r i a l s				
		1st	2nd	3rd	4th	
	1.	T	T	T	T	
	2.	T	T	T	A	
	3.	T	T	A	T	
(*)	4.	T	A	T	T	
	5.	A	T	T	T	(*) The first three trials
	6.	T	T	A	A	were "T-A-T"
(*)	7.	T	A	T	A	
	8.	T	A	A	T	
	9.	A	T	T	A	The Probability that the 4th
	10.	A	T	A	T	Try will be "T" is 1/2.
	11.	A	A	T	T	
	12.	T	A	A	A	∴ We Can't Learn A Thing!!
	13.	A	T	A	A	
	14.	A	A	T	A	
	15.	A	A	A	T	
	16.	A	A	A	A	

Figure 6.2: Unconditioned Probability Space.

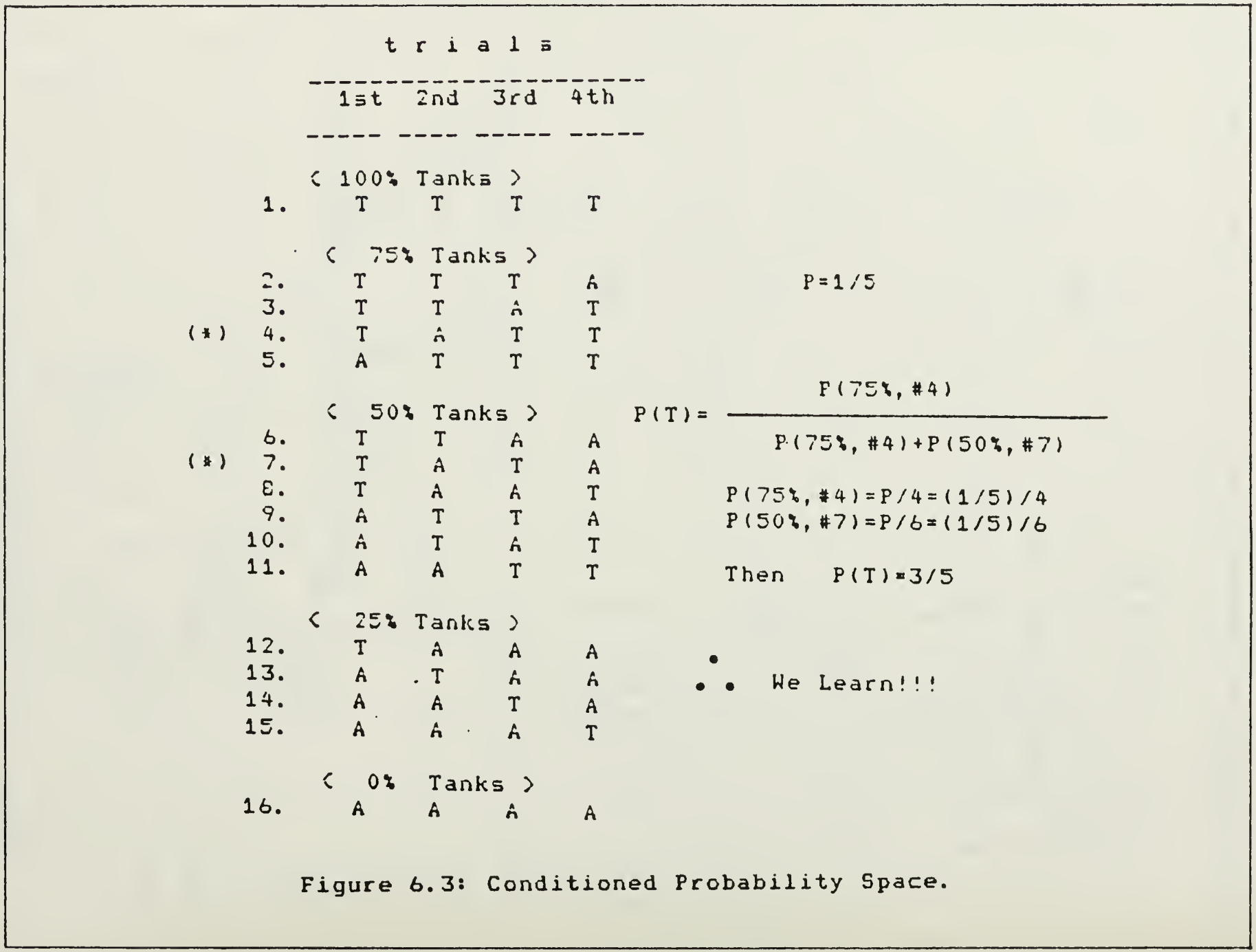


Figure 6.3: Conditioned Probability Space.

SENSORS	ERROR TYPE α	ERROR TYPE β
A	$P*(1-Pd(A))$	$(1-P)*Pn$
A U B	$P*(1-Pd(A))*(1-Pd(B))$	$(1-P)*(1-Pn(A))*(1-Pn(B))$
.		
.		
.		
A U B U..U N	$P*\prod_{i=1}^{r}(1-Pd(i))$	$(1-P)*(1-\prod_{i=1}^{r}(1-Pd(i)))$
<---- r --->		

Figure 6.4: Union of Sensors and Errors of Types a & b.

$$E(L) = \alpha * L1 + \beta * L2$$

$$I[(A \cup B), A] = (E(L(A)) - E(L(A \cup B)))/E(L(A))$$

$$I[(A \cap B), A] = (E(L(A)) + E(L(A \cap B)))/E(L(A))$$

E(L) : Effective Loss By Sensor(s) Being Used

I % : Improvement of Later Sensors Over First Sensor

L1 : Loss Associated With Type I(α) Error

L2 : Loss Associated With Type II(β) Error

Figure 6.5: Improvement of Later Sensors over First Sensor.

VII. EPILOG

The primary purpose of this study was to produce a conceptual framework that would outline from a system's context how a SACS (Staff Assistant Computer System) would be used to support staff operations within the LAF (Large Army Formation). Another purpose was to present some mathematical models for assisting the intelligence inference beyond the experience and the perception or intuition of the intelligence analyst. Thus this study had two main objectives. The first was to develop concepts for using a SACS to assist in accomplishing critical functions, duties, and tasks that must be performed within those command and control elements of the LAF which will be affected by the introduction of the SACS. The study in part was elaborated to provide as much detail as possible (the interface with a LAF wasn't possible) in a conceptual system description. This foundation is needed by developers to continue the analysis to the next level of a detailed study dealing with the behavior and skills associated with the design, development, and use of the several sets of hardware and software.

Through the analytical effort involved in satisfying the first objective of the study, it was possible to identify critical command and control duties related to the military intelligence, that appeared impossible to perform effectively

given current manual procedures and projected SACS software capabilities. Thus identification of the need for new tools to support the intelligence inference constituted the second major thrust of this study.

APPENDIX A

PROGRAM LISTING

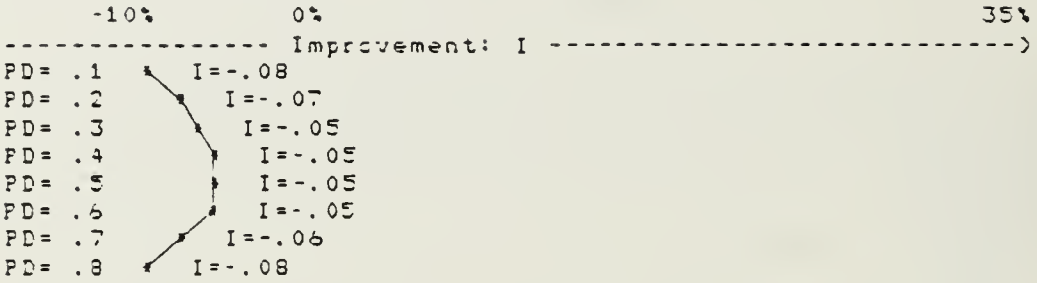
*** PROGRAM LISTING ***

```
10  REM A PLOT OF THE "I" VS "PD" FOR REASONABLE VALUES OF "P"
15  REM IN THE CASE OF THE UNION OF TWO SENSORS A,B: (A U B)
20  LET L1=50
30  LET L2=10
40  LET PN=.3
50  FOR P=.1 TO .9 STEP .1
52    LPRINT
53    LPRINT
57    LPRINT "              UNION  OF  TWO  SENSORS"
58    LPRINT "P%=";INT(P*100)
59    LPRINT "      -10%         0%                                          35%"
60    LPRINT "----------------- Improvement: I ----------------------------->"
61    FOR PD=.1 TO .9 STEP .1
70      LET U=(P*(1-PD)*PD*L1-(1-P)*PN*(1-PN)*L2)*100
80      LET A=P*(1-PD)*L1+(1-P)*PN*L1
90      LET I=U/A
100     LPRINT "PD=";INT(PD*100)/100;TAB(17+I);"*  ";"I=";INT(I)/100
110   NEXT PD
120 NEXT P
130 END
```

```
10  REM A PLOT OF THE "I" VS "PD" FOR REASONABLE VALUES OF "P"
15  REM IN THE CASE OF THE INTERSECTION OF TWO SENSORS A,B: (A ∩ B)
20  LET L1=50
30  LET L2=10
40  LET PN=.3
50  FOR P=.1 TO .9 STEP .1
52    LPRINT
53    LPRINT
54    LPRINT "       INTERSECTION  OF  TWO  SENSORS"
58    LPRINT "P%=";INT(P*100)
59    LPRINT "      0%         10%                          35%                  "
60    LPRINT "----------------- Improvement: I ----------------------------->"
61    FOR PD=.1 TO .9 STEP .1
70      LET X=(P*(1-PD)*PD*L1+(1-P)*PN*(1-PN)*L2)*100
80      LET A=P*(1-PD)*L1+(1-P)*PN*L1
90      LET I=X/A
100     LPRINT "PD=";INT(PD*100)/100;TAB(10+I);"*  ";"I=";INT(I)/100
110   NEXT PD
120 NEXT P
130 END
```

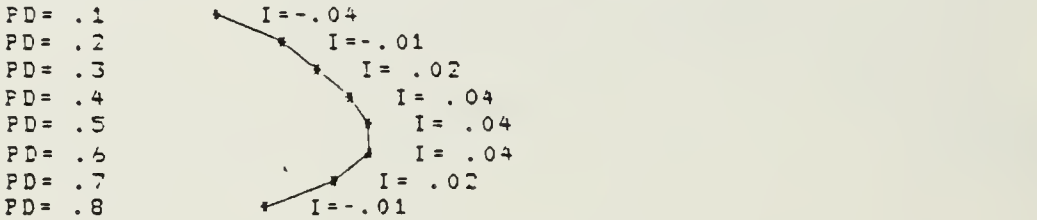
UNION OF TWO SENSORS

P%= 10



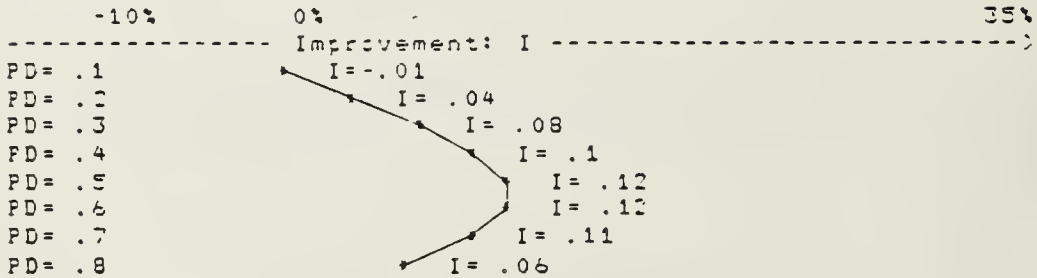
UNION OF TWO SENSORS

P%= 20



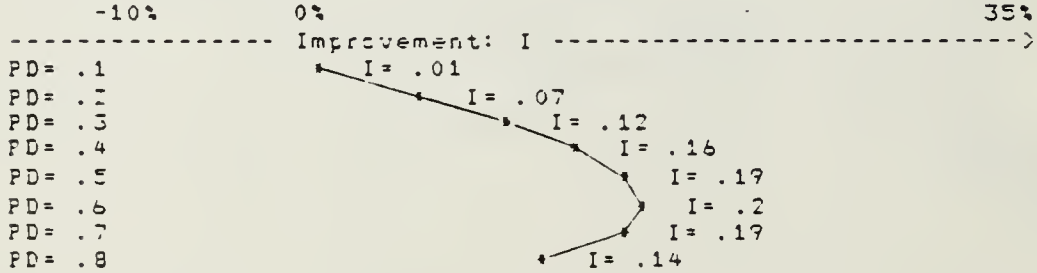
UNION OF TWO SENSORS

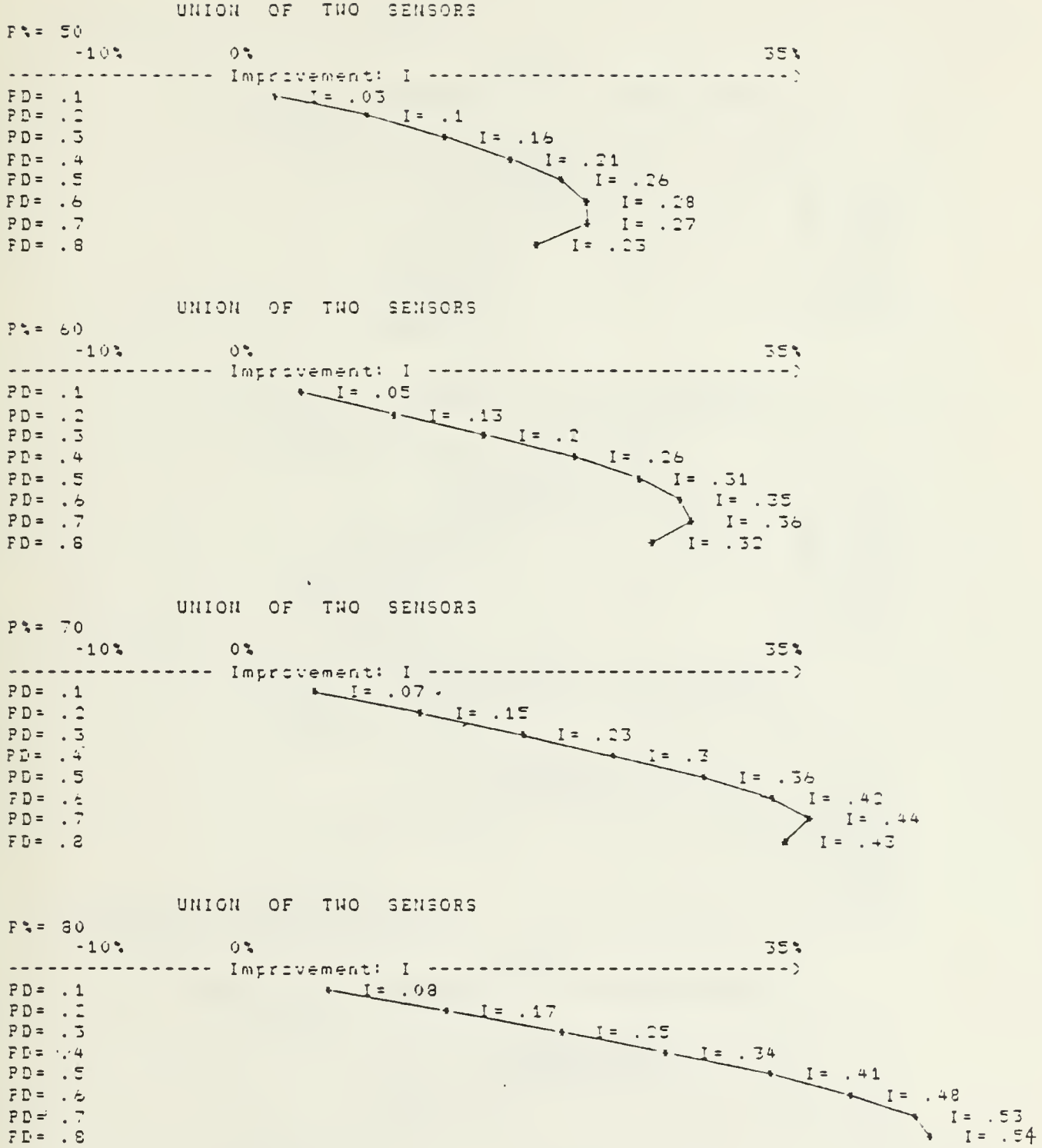
P%= 30

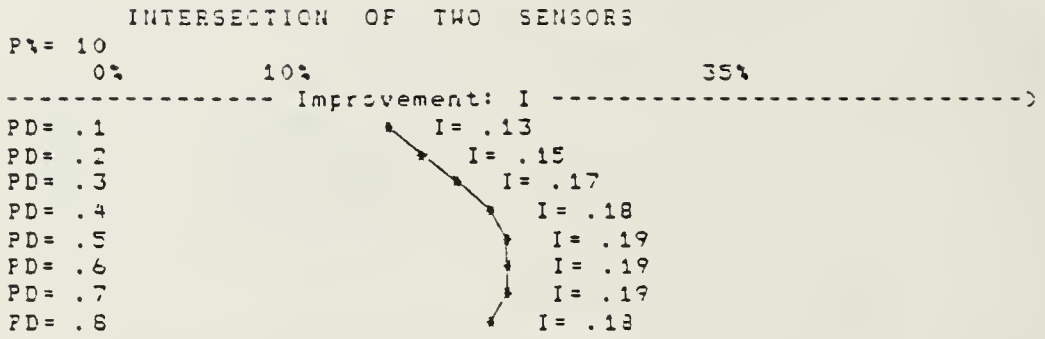


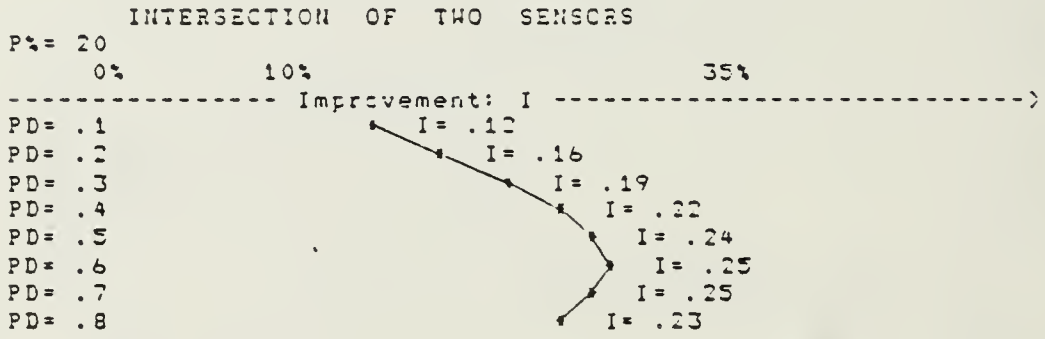
UNION OF TWO SENSORS

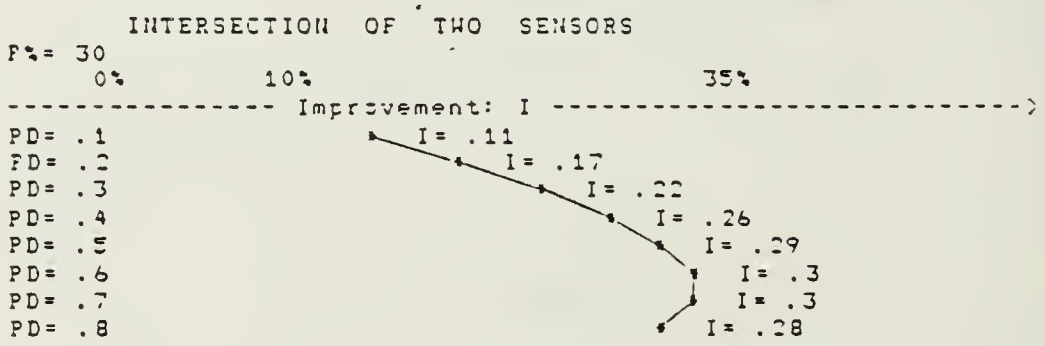
P%= 40

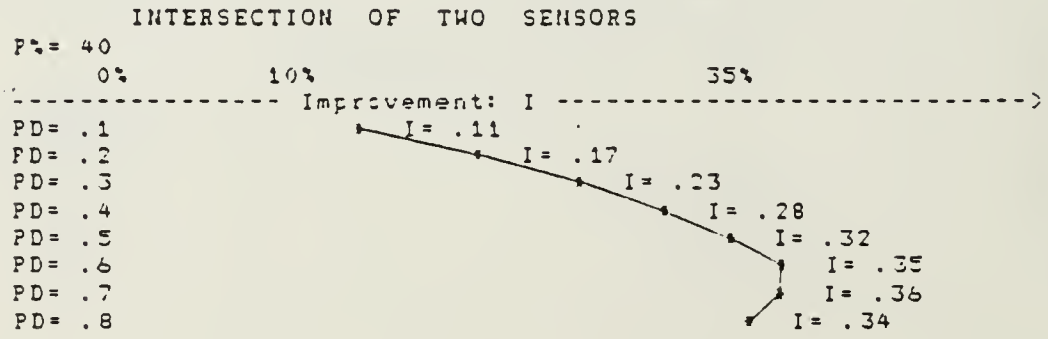


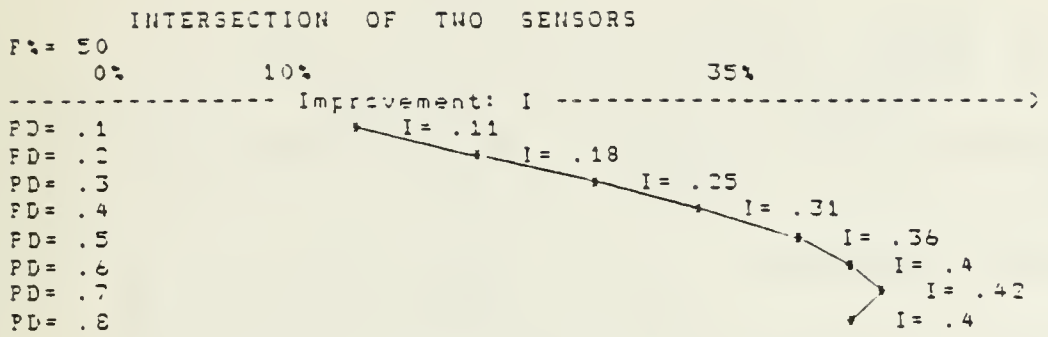

UNION OF TWO SENSORS
P%= 50
-10%
0%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .03
I= .1
I= .16
I= .21
I= .26
I= .28
I= .27
I= .23
UNION OF TWO SENSORS
P%= 60
-10%
0%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .05
I= .13
I= .2
I= .26
I= .31
I= .35
I= .36
I= .32
UNION OF TWO SENSORS
P%= 70
-10%
0%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .07
I= .15
I= .23
I= .3
I= .36
I= .42
I= .44
I= .43
UNION OF TWO SENSORS
P%= 80
-10%
0%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .08
I= .17
I= .25
I= .34
I= .41
I= .48
I= .53
I= .54

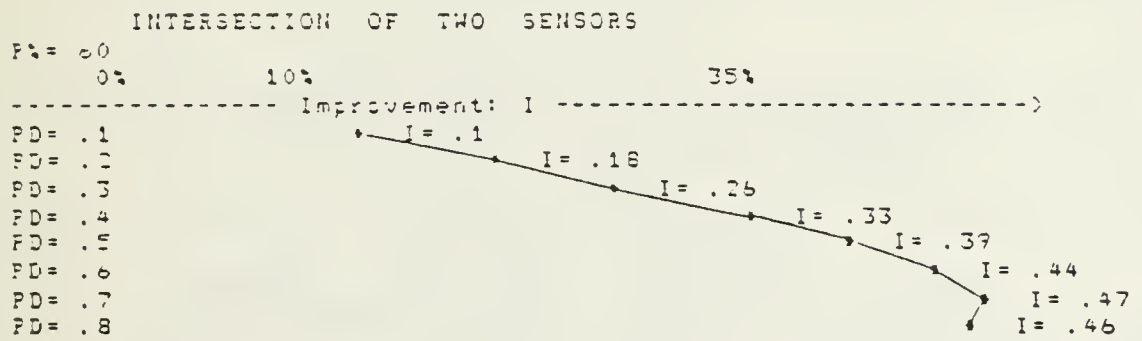

INTERSECTION OF TWO SENSORS
P%= 10
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .13
I= .15
I= .17
I= .18
I= .19
I= .19
I= .19
I= .18

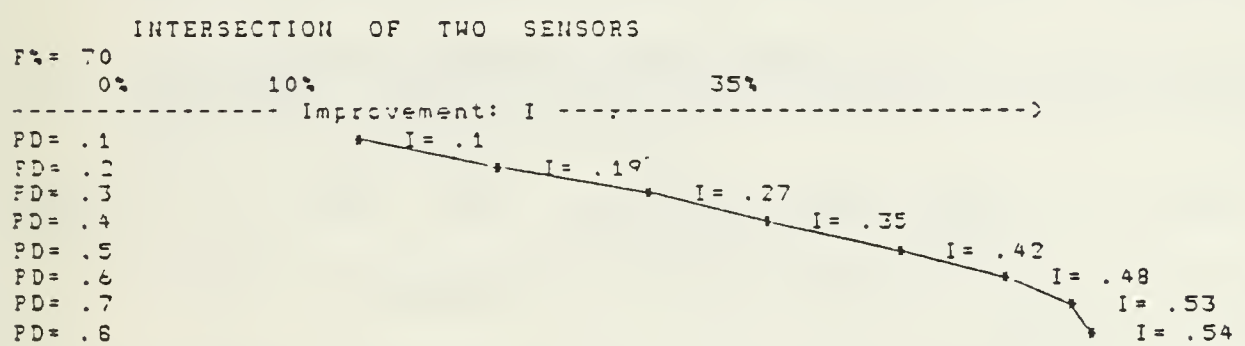

INTERSECTION OF TWO SENSORS
P%= 20
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .12
I= .16
I= .19
I= .22
I= .24
I= .25
I= .25
I= .23

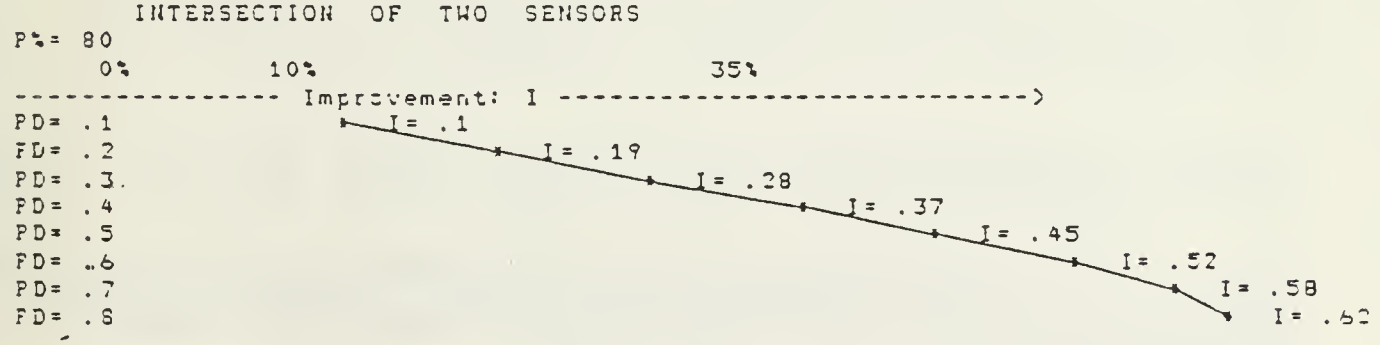

INTERSECTION OF TWO SENSORS
P%= 30
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .11
I= .17
I= .22
I= .26
I= .29
I= .3
I= .3
I= .28


INTERSECTION OF TWO SENSORS
P%= 40
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .11
I= .17
I= .23
I= .28
I= .32
I= .35
I= .36
I= .34


INTERSECTION OF TWO SENSORS
P%= 50
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .11
I= .18
I= .25
I= .31
I= .36
I= .4
I= .42
I= .4


INTERSECTION OF TWO SENSORS
P%= 60
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .1
I= .18
I= .26
I= .33
I= .39
I= .44
I= .47
I= .46


INTERSECTION OF TWO SENSORS
P%= 70
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .1
I= .19
I= .27
I= .35
I= .42
I= .48
I= .53
I= .54


INTERSECTION OF TWO SENSORS
P%= 80
0%
10%
35%
Improvement: I
PD= .1
PD= .2
PD= .3
PD= .4
PD= .5
PD= .6
PD= .7
PD= .8
I= .1
I= .19
I= .28
I= .37
I= .45
I= .52
I= .58
I= .62

LIST OF REFERENCES

1. Gore, M. & J. Stubbe, Elements of Systems Analysis, WCB 1983, pp. 51-63.

2. Staff Organization and Procedure, Hellenic Army General Staff, 1975.

3. The Large Army Formation, Hellenic Army General Staff, 1978.

4. TM-6009/000/00, Systems Development Corporation, February 1978.

5. Clark, J.H., "The Geometry Engine a VLSI Geometry System for Graphics," Computer Graphics, July 1982.

6. "Computer Security," Military Electronics, February 1982.

7. Bartee, T.C. and O.P. Bruneman, IDA Paper P-1637 Institute for Defense Analyses Science & Technology Division, April 1982.

8. Deitel, H.M., An Introduction to Operating Systems, Addison-Wesley Systems Programming Series, 1982, pp. 453-454.

9. Ullman, J., Data Base Principles, CSP, 1982, pp. 206-209.

10. Martin, J., An End User Guide to Database, J. Martin Series, 1983.

11. Chang, N.S., and K.S. Fu, "Picture Query Language for Pictorial Data Base Systems," Computer, November 1981, pp. 23-33.

12. Zloof, M., "A Language for Office and Business Automation," Office Automation Conference Digest, March 1980, pp. 260-280.

13. Lee, Norman, An Account of the Heuristics in the Conceptual Design of a Data Processing System for Military Intelligence Inference, Army Electronics Command, Fort Monmouth, New Jersey, April 1975, pp. 40-151.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943	2
3.	Maj. (HA) Spyridon Kalyvas Helenic Army General Staff Artillery Direction Stratopedo Papagou Holargos, Athens, GREECE	7
4.	Maj. (HA) Panagiotis Tsagaris SMC #2697 Naval Postgraduate School Monterey, California 93943	1
5.	Maj. (HA) Athanasios Kanellos SMC #1517 Naval Postgraduate School Monterey, California 93943	2

13537 5

210311

Thesis
K12432 Kalyvas
c.1 Systems analysis for
large army formations.

24 JUL 87 33480

210311

Thesis
K12432 Kalyvas
c.1 Systems analysis for
large army formations.

thesK12432
Systems analysis for large army formatio
3 2768 002 11382 1
DUDLEY KNOX LIBRARY